



# **DiVA** 2016

## **11<sup>th</sup> International Scientific Conference on Distance Learning in Applied Informatics**

**Conference proceedings**

**May 2 - 4, 2016**

**Štúrovo, Slovakia**



**Wolters Kluwer**

Constantine the Philosopher University in Nitra  
Faculty of Natural Sciences  
Department of Computer Science

and

University of Hradec Králové  
Faculty of Science  
Department of Informatics

# **DIVAI 2016**

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Learning in Applied Informatics

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**DIVAI 2016**

11<sup>th</sup> International Scientific Conference on Distance Learning in Applied Informatics

**Publisher:** Wolters Kluwer

**Edition:** 2422

**Organized by:**

Constantine the Philosopher University in Nitra

University of Hradec Králové

OZ DIVAI (Dištančné vzdelávanie v aplikovanej informatike) Nitra

**Partners:**

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**Editors:** Milan Turčáni, Zoltán Balogh, Michal Munk, Ľubomír Benko

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ISBN 978-80-7552-249-8

ISSN 2464-7470 (Print)

ISSN 2464-7489 (On-line)

Papers are printed as delivered by authors without substantial modifications. All accepted papers have been double-blind reviewed.

# Preface

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Dear readers!

Fourteen years ago the Department of Informatics, Faculty of Natural Sciences, Constantine the Philosophy University in Nitra decided to organize a conference focusing on the application of ICT into the instruction of informatics subjects. The very first years of the conference we were very careful about the number of participants. Participants came mostly from departments of informatics from the universities in the Czech and Slovak Republic, which was mainly connected with the considerable resentment of other fields to use modern information technologies for the support of instruction at their workplaces. In the first few years of the conference, which was called DIVAI (Distant Education in Applied Informatics) the powerful community of experts on informatics succeeded in proving that supporting education using the tools of Internet has its substantiation and a permanent place mainly in the distant form of educating the students.

The conference within the university education has one thing in common and that is utilization of services and tools of Internet, thus eliminating barriers for permanent cooperation in this sphere.

After finishing 9th conference and based on the reviews and the feedback from the participants of the conference we sent our outcomes of the event in the form of proceedings from the conference into the database WoS Thomson Reuters for indexing process. After a certain period of waiting we were surprised by a message on positive evaluation and the subsequent indexing of the proceedings in the WoS database. At the 11th conference we are ready to publish the accepted and reviewed contributions in the printed form of serious quality. We have asked for its realization the renowned publishing house Wolters Kluwer, which has its representation in Prague. We believe that after serious reviews and selection of those best contributions you will receive professional material from the sphere of university instruction using modern information means of a very good quality.

I want to express my best thanks in this form to all members of the programme committee, as well as members of the organizing committee for their willingness and helpfulness at preparation and during the course of the conference DIVAI 2016 and editing of the final publication, which will be sent for indexing to WoS database of Thomson Reuters and database Scopus. We believe that the publication will be positively accepted not only by the readers, but also by the evaluators from the Thomson Reuters and Scopus publishing house.

In conclusion of this preface I wish all the readers of the outcomes of the conference coming from professional practice, as well as all those interested in these issues on all levels of education a quality experience and discovery of new knowledge in the given area.

Milan Turčáni

Conference chair



# Conference Organization

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## **Keynote Lectures**

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# Putting Learners' Experience at the Center of Technology Enhanced Learning, or How Students Can Learn More While Enjoying Their Classes

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## Abstract

*While educational paradigms have been cast under the traditions of cognitivism, behaviorism, and constructivism, the humanistic approach to education has only rarely been recognized as forming the didactical baseline in technology enhanced learning. In this paper we present, illustrate and discuss the potentials of person-centered, experiential learning when supported to live in a symbiosis with web-technology. The resulting approach is referred to as Person-Centered technology enhanced Learning (PCeL). By presenting illustrative examples, research results, and numerous students' reactions to this educational style, this paper aims to provide educators with a well-founded, realistic image and conceptualization of person-centered, technology enhanced learning. In particular, the encouraging results from two large universities employing PCeL for providing experiential learning in the realm of students' interpersonal competences aside of intellectual knowledge, and improving participants' learning experience are presented. Foremost, these models, illustrations and results are intended to inspire educators in their own educational practice and research.*

## Keywords

*Person-Centered technology enhanced Learning. Person Centered Approach. Carl Rogers. Experiential learning. Learner-centered instruction.*

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## INTRODUCTION

Current educational strategies in the European Union encourage educational styles that are targeted at the development of attitudes and skills side by side with knowledge construction (Méhaud & Winch, 2013). Once skills and attitudes are involved, the resulting teaching/learning processes can't restrict themselves to rote learning of facts and necessarily need to involve the learners' whole-person experience, including their feelings,

meanings, and often also activities. The hypothesis we're putting forth here is that technology-enhanced settings, if introduced skilfully and sensitively, tend to offer more potential to supporting experiential, whole person learning than the classical pure face-to-face setting. This is mainly because the scope of activities and both personal- and material resources are enhanced when compared to the classical pure face-to-face setting.

However, even though technology can vastly extend the repertoire and scope of learning resources and activities – and this article will provide several inputs and scenarios on this – to be fully effective, any educational offering requires the learners to commit themselves to the learning process, to accept it, and to engage themselves as fully as possible. This requires learners' openness to the educational offering and their trust in both the offering and themselves to achieve the results they aspire. This commitment and trust tends to be developed through the interpersonal relationship with a significant other person, often the teacher, instructor, or facilitator.

According to Carl Rogers, an early pioneer of person-centered learning, the contribution of the interpersonal relationship to the facilitation of significant, experiential learning is vital. Rogers wrote:

“We know ... that the initiation of such learning rests not upon the teaching skills of the leader, not upon scholarly knowledge of the field, not upon curricular planning, not upon use of audio-visual aids, not upon the programmed learning used, not upon lectures and presentations, not upon an abundance of books, though each of these might at one time or another be utilized as an important resource. No, the facilitation of significant learning rests upon certain attitudinal qualities that exist in the personal relationship between the facilitator and the learner.” (Rogers, 1983, p. 121)

This is why, in the current context of technology-enhanced learning (see Section 2), we're highly interested in the interpersonal qualities and attitudes that make for a constructive atmosphere and a trustful learning climate, void of fear and devaluation, and full of facilitative interaction. In fact, more recent research is confirming the vital importance of the quality of the interpersonal relationship for learning. For an extensive meta-study on learner-centered instruction see (Cornelius-White and Harbaugh, 2010), for a broader scope and indicators consult the various sources on John Hattie's work on “Visible Learning”. More specifically, the role of the interpersonal relationship in modern, technology enhanced settings such as the “flipped classroom” is discussed in (Harbaugh and Cornelius-White, 2013). The individual dimensions of added value of Person-Centered, technology enhanced Learning (PCeL) and respective research results are described in (Motschnig-Pitrik, 2013). However, an exploration of related work wouldn't be complete if it didn't mention Rogers' original, ground-breaking work: In his book “Freedom to learn for the 80's”, Rogers (1983) devoted a whole chapter to “The Interpersonal Relationship in the Facilitation of Learning” and another one to research. He provided a rich reference list and included findings by David Aspy and Flora Roebuck in the USA and by Reinhard and Annemarie Tausch in Germany.

Currently, the Person-Centered Approach (Rogers, 1961), developed by the American psychologist Carl Rogers is adopted and enhanced by the use of web-technology in an approach that the author and her colleagues named PCeL, Person-Centered, technology enhanced Learning. PCeL is practiced and researched in several technology enhanced educational settings. In the authors' view it holds great promise in promoting sustainable,

experiential, whole person learning and makes a positive difference to students' experiential field, professional life, and (inter-)personal satisfaction.

We need to emphasize that in the following, it is absolutely not our goal to argue that PCeL is the paradigm that is best suited for any learning situation. This is far from what we want to say. It is our intention however, to show that there exist opportunities in which PCeL courses can make a positive difference in the students' attitudes towards learning, teams, and, in general, interpersonal relationships and communication. This positive difference tends to extend to both the professional and private lives of students and, to a remarkable degree, also of facilitators. These may benefit/grow from the fresh and creative responses of students, from meeting new challenges when trying to accompany students in solving real problems, and from the required flexibility when needing to meet students' real needs and requirements posed by the respective curriculum, to name just a few sources for teachers' learning.

This paper is structured as follows: The next Section presents core features of person-centered learning and its symbiosis with web-technology, resulting in PCeL. While Section two focuses on conceptual and theoretical aspects, Section three illustrates applications of PCeL in academic courses in the context of applied computer science. Section 4 is devoted to the evaluation and assessment of PCeL courses and their effects on students' internships in companies. In a nutshell, students stated that they considered exchange and discussion with colleagues and active participation during the course as the top factors from which they benefited. Furthermore, the majority of students felt that it was easier for them to work in teams and to establish social relationships in PCeL courses than in traditional courses. The final Section rounds up the paper and indicates areas for further research.

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## PERSON-CENTERED, TECHNOLOGY ENHANCED LEARNING

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In order to understand the essence of PCeL we need first to attend to its precursor, student- or person-centered learning, developed by Carl Rogers in the second half of the previous century, based on humanistic educational principles and objectives. Carl Rogers distinguished between learning that involves the mind only, such as rote learning of facts, and so called "significant, meaningful, experiential learning." As an example of the latter he describes the experience when "the toddler touches the warm radiator and learns for herself the meaning of the word *hot*; she has learned a future caution in regard to all similar radiators [...] in a significant, involved way that will not soon be forgotten." By significant learning Rogers designates "learning which is more than an accumulation of facts. It is learning *which makes a difference* – in the individual's behavior, in the course of action he chooses in the future, in his attitudes and in his personality. It is a pervasive learning which is not just an accretion of knowledge, but which interpenetrates with every portion of his experience" (Rogers, 1961, p. 280).

To Rogers, his personal experience was the highest authority. It was to experience that he had to return again and again, in order to discover a closer approximation to truth. Rogers (1961, p. 25) wrote: "My experience is not authoritative because it is infallible. It is the basis of authority because it can always be checked in new, primary ways. In this way its frequent error or fallibility is always open to correction." From this follows Rogers'



conviction and corresponding attitude as a facilitator, namely that there is no philosophy or set of principles which he would persuade others to accept. Given the current emphasis on teaching, this is a radically different standpoint. Rogers stated (1961, p. 27): "I can only try to live by *my* interpretation of the current meaning of *my* experience, and try to give others the permission and freedom to develop their own inward freedom and thus their own meaningful interpretation of their own experience."

In a nutshell, "significant learning combines the logical and the intuitive, the intellect and the feelings, the concept and the experience, the idea and the meaning. When we learn in that way, we are whole..." (Rogers, 1983, p. 20).

Person-Centered Learning is based on the empirically proved hypothesis (Aspy, 1972) that students achieve superior academic results and even personal growth in terms of higher self-confidence, openness to experience, etc., if they learn in an atmosphere or climate that can be characterized by three basic attitudinal conditions: realness, acceptance, and empathic understanding.

- *Realness*, genuineness, or transparency in the facilitator means that he or she must be real in the relationship with his/her student, be the person he/she is and not use any masks of facades in communicating with the students.
- *Acceptance*, prizing, or respect towards student implies that the facilitator accepts and respects the whole personality of the student and feels basic trust in his or her constructive tendency, his/her striving for solutions in his/her own way.
- Deep understanding, often called *empathic understanding*, means that the facilitator actively listens to the students with the ultimate goal to profoundly understand their questions, motivations, intentions, and the meanings of their communication as well as solutions.

These conditions must be held or lived by the instructor/teacher or facilitator, and reciprocally be perceived by the students to be effective. Besides the above attitudinal conditions that contribute to establishing a facilitating, fruitful atmosphere for learning, Carl Rogers (1961) observed that significant, experiential learning would occur more readily in relation to situations perceived and recognized as problems by those who wish to learn. Students in mandatory courses are apt to view the course as an experience in which they expect to remain passive. The essential implication of this observation is that we need to permit students, at any level, to be in real contact with problems *they* consider relevant, so that they perceive problems and issues they really care about and wish to resolve. Thereby the basic humanistic hypothesis upon which the teacher builds is that students who are in contact with real problems wish to learn, want to grow, seek to find out or desire to create. Hence, the teacher sees his/her function as that of developing a climate in the class that these inherent tendencies can unfold. Thus, rather than acting as an expert and "implanting" or imposing information on students, the teacher becomes a facilitator of learning. By holding the three attitudinal conditions of realness, acceptance and deep understanding, and by providing appropriate personal-and material resources, the facilitator genuinely trusts that significant, experiential learning will occur. Briefly, Person-Centered Learning requires particular personal attitudes from the facilitator and at least a certain degree of openness from the curriculum as well as the students. A brief juxtaposition between pedagogical features of traditional and PCeL approaches to teaching and learning is depicted in Table 1.

Table 1: Traditional versus Person-Centered technology enhanced learning.

	Traditional	Person-Centered technology enhanced Learning (PCeL)
Learning targets	instructor	participative, cooperative
Transfer direction	instructor → learner	cooperative, multiple perspectives, flexible
Transfer mode	lecture	offering, exchange, sharing, interaction, forum, moderation, presentations
Instructor's role	expert	facilitator, coach, mentor, mediator
Tasks	constructed	authentic, situative

As a consequence of what has been said above, the facilitation of experiential learning is likely to involve some of the following elements (Rogers, 1983; Motschnig and Nykl, 2014):

- It builds upon problems perceived as having meaning and relevance for students
- Accessibility of material resources, such as tutorials, books, or training information
- Provision of personal resources, using the community, and making oneself available as a resource
- Peer teaching and peer evaluation (Derntl et al., 2006)
- Use of learning contracts (Standl et al., 2012)
- Cooperative learning in small groups
- Helping students to become inquirers working toward scientific discovery
- Self-evaluation and reflection taking account of the evaluation of one's own learning (Derntl et al., 2006)
- Intensive group/workshop experience and reflection (Motschnig-Pitrik, 2015).

These elements actually build the bridge to technology enhanced learning (Bauer et al. 2006). This is because technology can facilitate, in the sense of making simpler, faster, better accessible, or more practical, the elements enumerated above. Before looking at how this can work in an academic course, let us get back to the core of person-centered learning – the three attitudinal conditions – and share how they can be expressed in technology enhanced environments.

**Extended interpretations of the person-centered core conditions.** In the following, we're going to extend the psychological meaning of the three core conditions to include a broader scope and give examples, how these conditions can be expressed in technology enhanced environments.

**Realness.** Rogers' notion of congruence, realness, openness, or transparency of the facilitator can be extended to include:

- Real problems, situated setting, online learning contracts
- open feedback
- transparent goals and criteria for evaluation
- transparent expectations, fears, reactions, multiple perspectives;

Note that realness, openness and honesty are “contagious”, once perceived, they are more easily expressed by the recipient.

**Acceptance.** Rogers' notion of acceptance of the whole person, unconditional positive regard, or respect can be expressed in various ways including:

- Students' participation in all aspects of learning, such as elaborating goals, choosing topics, suggesting projects
- encouragement of self-initiated contributions
- trust in constructive team work, where individuals can complement one another
- self-evaluation and peer comments as an expression of hearing the other's voice

Feeling respected nourishes respect for others and thus significantly contributes to a climate in which students feel welcome whatever their background, nationality, knowledge, skills, etc.

**Empathic understanding** has been introduced as a deep kind of listening to the other with the ultimate goal to profoundly understand them from their perspective. This meaning can be extended to include:

- Deep listening not only at an individual level but also at a group-or class level
- empathically receiving the learning environment: how is the atmosphere in the room, what equipment is available?
- empathically receiving the momentary situation: how are the students right now, are they fresh or tired, exhausted from a test, excited by some recent happening, etc.?
- exploiting particular situations for learning, such as:
  - Situated course design
  - Balance between choices and curriculum requirements
  - Giving students space and time to find their ways;

**Contribution of technology.** In applied thoughtfully, technology can significantly facilitate the expression of person-centered conditions in their extended scope. This is in part due to the increased scope of activities in which both students and instructors can take part (“con-tribute”) in the course. The following list exemplifies some of these activities:

- Provision of material via an eLearning platform: vast resources serve as a basis for selection such that students can be offered choices
- every participant is expected to contribute actively in some form
- learning from more than one example is facilitated by putting all peer projects are online
- transparency is increased by making all course information available online

- asking for students' online reaction sheets after each course unit; these can be referred to during the next meeting and help to build bridges between units
- discussion forum, WIKI-spaces for allowing for contact between the units
- provision of contact to resources outside the course setting
  - persons, experts, community, etc.
  - material via Internet, remote access, contact to sponsors, etc.
- oral and written forms of expression are encouraged such that there are multiple ways to contribute
- peer evaluation becomes more practicable over a web-space and hence more feasible
- research is easier to conduct due to online questionnaires and documents to be analyzed
- reactions/reflections can be made available to other students.

It must be kept in mind, however, that all these online provisions and activities require thoughtful preparation and attention to be effective. They tend to consume considerable amounts of teachers' as well students' time and thus should be carefully integrated into the course concepts such as to really add value to experiential learning. PCeL thus far has been applied to several courses in the context of computer science such as software engineering, project management, web-engineering, human-computer interaction, organizational development and beyond, for example in teacher-training, psychology, economy, and service-science (Motschnig-Pitrik and Standl, 2013), (Pitner, 2014). For this article, we choose to illustrate its application in a course on "Communication and Soft Skills" (CSS). The choice is based on the fact that CSS is kind of "typical" for applying PCeL, it has no rigid curriculum to follow, is conducted with rather small groups (12 – 22 students) and its effects have repeatedly been researched at two major universities (University of Vienna and Masaryk University).

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## APPLYING PCEL IN A TECHNOLOGY ENHANCED COURSE ON COMMUNICATION AND SOFT SKILLS

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The course "Communication and Soft Skills"(CSS) has been developed as an intensive, technology enhanced lab-course at the University of Vienna, Faculty of Computer Science, and subsequently adopted at the Masaryk University in Brno.

**Course goals and concept.** The primary goal of this course is to allow students to improve their competence in communication, teamwork, moderation and other soft skills based on the students' actual demands. In the course students are expected to share knowledge and competencies regarding active listening, person centered communication, moderation techniques, team development, conflict management and related issues. The course is based on active, person-centered learning in a constructive atmosphere and includes several practical exercises. The instructor takes on the role of a facilitator and moderator providing resources. Students are expected to work in teams of about 3 persons to elaborate topics in a self-directed way and to prepare moderated units (lasting for about 2,5 hours each and including a break) and simple online materials for all participants. The course evaluation takes into account the students' active participation in



face-to-face and online phases, the materials elaborated, the quality of the unit moderated, and includes an element of self-evaluation.

In the following, we describe the course scenario along with a conceptual model that is intended to capture the essential activities for the sake of reuse. Figure 1 illustrates the course scenario using an UML activity diagram with stereotype extensions (Rumbaugh et al., 1999). The swim lanes serve to relate activities and document flows with those actors that play the central role and frequently control the respective activities. This allows for intuitive gross estimates on the degree of instructor- or student-centeredness of courses at first glance.

In order to provide room for active interaction in class, fundamental material, links, and a list with references to further literature are supplied by the instructor over the learning platform at the time of course initialization. Also, key data on the course such as time, location, goals, brief description, etc. are provided such that students have initial information before enrolling in the course. The respective activity ("Create course space...") primarily proceeds on the Web and hence is stereotyped with a "W" icon in Figure 1.

The initial meeting, stereotyped with a "P" icon standing for "present", is used to discuss the innovative course style, requirements, and learning methods, as well as to introduce the learning platform and to finalize the list of participants. Then students are asked to fill out an online questionnaire aimed at capturing their initial motivation, attitudes towards learning, ways they tend to profit from academic courses, etc. Furthermore, students are asked to assign themselves to small teams of about three to four students for cooperative work.

The face-to-face thread of the course consists of ten moderated workshops, 4 hours each, where individual topics within the gross framework of "soft-skills in project management" are elaborated following a strongly interactive style. The first three workshops are moderated by the instructor who uses various techniques to introduce students practically such as team discussions, collection of issues on a flip chart, moderation cards, mind maps, role playing, etc. Accompanying descriptions of these techniques and more theoretical background on their application is provided via the learning platform and can be inspected on demand. The remaining seven workshops are prepared by teams of students on topics we agree upon during the initial sessions. Preparation of a workshop includes the provision of e-content regarding the selected topic, as shown in the document flow object produced by "Upload documents." Preparation also encompasses consultation with the instructor with regard to the moderation sequence and elements (included in "Prepare course unit", which is stereotyped with a "B" icon for denoting a blended activity). After each workshop, students submit online reaction sheets that can be read by all participants and are aimed at providing multi-perspective feedback to the team that moderated the workshop (the "active team" in Figure 1).

At any time, students have access to the basic material provided on the platform, as shown in the Web-centered activity "Download and view info on topics" of the course scenario. Concurrently, they are expected to briefly document their learning activities in a personal diary that shall support them in writing their self-evaluation in the end of the

course. Furthermore, a discussion forum is available for communication with the instructor, Web master, and fellow students on all course relevant issues.

At the end of the course students evaluate themselves online. This is accomplished by responding to questions such as: What did I contribute? What could I take with me from the course? How intensive was my contribution with respect to my team mates? etc. In addition, an online peer-evaluation is conducted in which each team evaluates all other teams in terms of their moderated workshop and the e-content they provided. Furthermore, students fill out a final online questionnaire that is used to evaluate the course on a more objective level. The self- and peer-evaluations are used by the instructor in his or her grading, thus complementing the grading process by an individual- and a group perspective reflecting the participative, student-centered didactic strategy inherent in course conception and design.

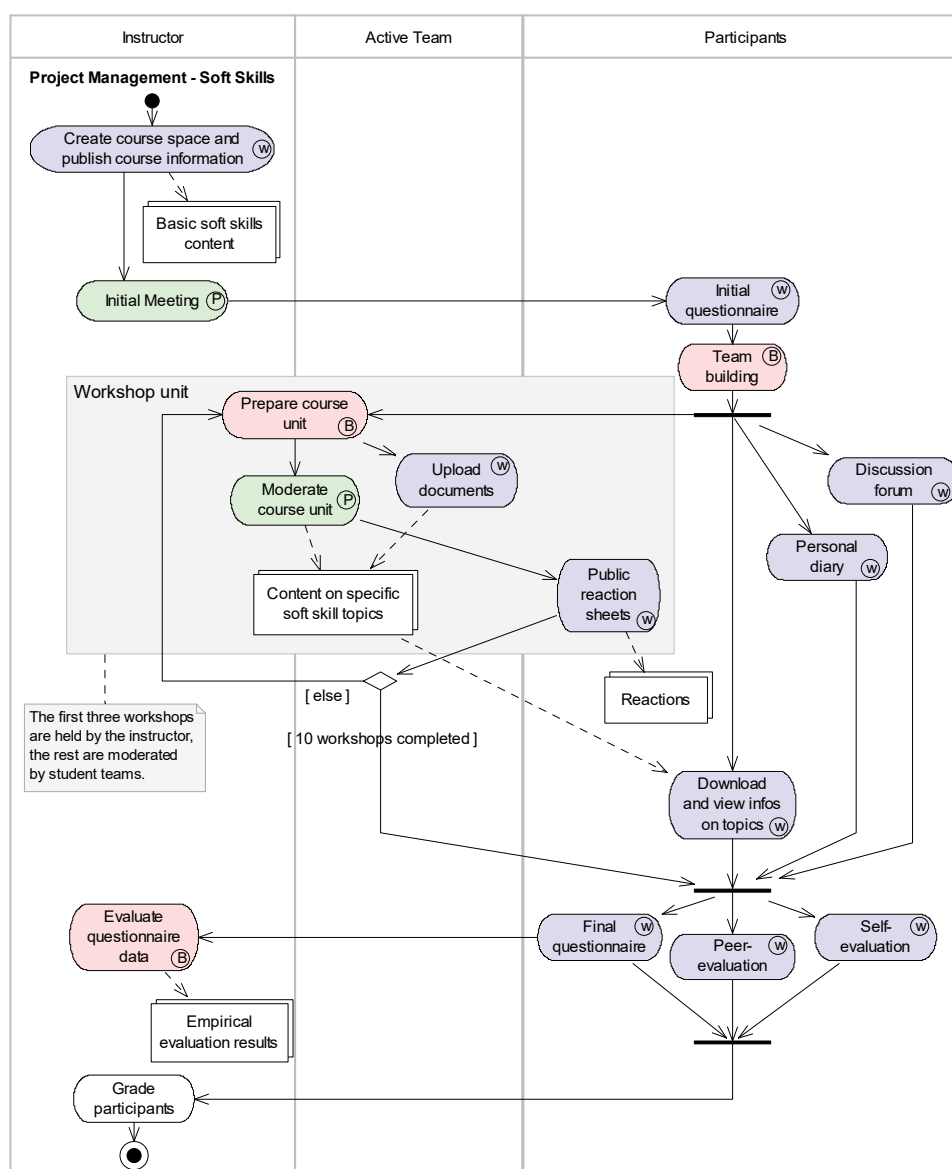


Figure 1: Course scenario blending face-to-face meetings with web-supported elements following a PCeL style (Motschnig-Pitrik and Derntl, 2005).

A first look reveals that the scenario has multiple threads and didactic elements (Motschnig-Pitrik and Derntl, 2005). In our view, however, this additional complexity adds significant value to the learning process, such as:

- More self-directed learning with more responsibilities of the learners and the group;
- Learning on the intellectual level, due to the elaboration of literature, as well as learning on the social and personal level due to intense teamwork and moderation of a course unit;
- More active participation and communication of students and instructor in face-to-face as well as online phases;
- More authenticity of the problems to be tackled can be achieved, since students can select problems and material and raise questions they find worth considering;
- More perspectives on the content/theories can be discussed;
- Students take on more roles. Besides being authors, moderators, presenters, and listeners, they are peers and comment on the work of others;
- More group orientation and cooperation.
- Explicit consideration and integration of qualitative and quantitative means of quality assurance allowing for participative, formative evaluation and improvement of the course.

We have experienced that the diagrammatic notation is indispensable for sharing the learning design with colleagues. Also, the choice of proper abstractions, names, and the provision of multiple grain sizes have proved essential in communicating didactical practice in general and in the contribution of technology-enhanced learning elements in particular.

In the scenario depicted in Figure 1, the activity “Peer-evaluation”, for instance, refers to a *pattern* (Gamma, 1995). This denotes a reoccurring activity sequence having a separate, reusable, activity diagram. PCeL patterns are discussed in more detail in (Derntl, 2005; Derntl and Motschnig-Pitrik, 2005). While the results of quantitative studies based on the initial and final online questionnaire of the course on Communication and Soft Skills are discussed in the Section on Evaluation, below we share excerpts from students’ self-evaluations of the most recent course instance (2015). The excerpts were chosen such as to reflect the students’ learning experience and be illustrative of the person-centered atmosphere.

“I’ll take from the course mainly the way it was led. I found more beneficial teaching methods we used [rather] than the usual teacher to student set up. Normally, I remember things only for a short while, but as here we practically tried a lot and thought about various different things influencing us, it was touching me a lot. [...] I know that I tend to speak a lot, but I hope I helped others to lose their fear and open up more. In the end, I was glad I attended the course, for example because it made me think more about the way I communicate with (and lead) people and what are the issues I want to work on.”

“I also had to cope with the quality of the presentation. I wasn’t so happy with it, but I had to let [my colleague] do it his way partly to let him try it for himself and also because I

didn't have time and capacity. This was difficult for me as I am quite a perfectionist and I know I need to work on this more because I can't control everything."

"At first, I have to say I learned a lot. I learned how a course can be taught in a very different way and how it is to speak in front of others for such a long time. I am no longer afraid of moderating for a longer period of time. I also gained a lot of useful information about communication, active listening, decision making, effectiveness, leadership and more. Now I see the big benefit which I get from me and others being honest and open all the time. For me the most significant experience was the moderation unit lead by a team of students. This possibility was really helpful and we as students do not have such chance in any other course at the university. [...] Another experience was how theory, interaction, discussions, games etc. could be mixed, thus we learn even more than if we just listened to a theory that a moderator presented. I found myself remembering a lot of information from all the units even if some time has passed and this is not the same with other courses. Learning from experiences and using a lot of interactive moderation elements is very useful not only for a course focused on Communication and soft skills. [...] As to some of my personal benefits, after this course I try to be a better active listener, more effective in whatever I do and not to be stuck in a point, to move forward and think of others even more."

An international student described his learning as follows (only an excerpt is quoted): "The opportunity to moderate a class was a significant experience for me because it was something that I never did before. [...] Also, the team work with other participants was one of the keys of our success during the presentation and, I think that this course helped us to be better in the team work part."

An international student who had missed the first block wrote: "I was waiting for the lesson to start as normally when the professor approached and asked friendly to present myself. Then we sat as a circle, a thing that I have never done before in another class and since that moment I knew that this class was going to be totally different from what I had already seen. And I was right the group and the professor welcomed me and made me feel comfortable since the first hour. I felt good and ready to share my opinion in every discussion. [...] This was the only course that I had the possibility to hear people express themselves regarding different situations, so I can say I learnt for their culture [...] and can easily find some differences between my culture and theirs. So every moment I had in this course was interesting and beneficial and every discussion or game that we played was a significant experience."

A Czech student (amongst others) expressed his appreciation for the international nature of the course: "Best thing I have learnt was how to moderate and lead the unit. Another great thing that I wouldn't change in this course was that it was in English and that it had Erasmus students participating. That was just great for the experience as a whole."

Another student appreciated the way the course was conducted: "I haven't ever experienced that a course was lead in this way. And I must say it was a very good experience. I liked that we, as students, lead the second and the third block. The learning, which I take with me the most, is probably active listening. I am trying to use it in my personal life much more than before and I think it is really profitable."

Our experience and students' reactions substantiate the added value of the more complex, technology-enhanced scenario. The particular benefit of conceptual modeling regarding quality assurance lies in the fact that questions as well as reactions can be associated with process phases and didactic elements, thus adding structure and transparency to researching technology-enhanced learning. Generally speaking, our solution regarding knowledge communication of the learning scenario lies in the specification of conceptual models as means of information sharing, improvement, and blueprints for deriving Web service support modules.

Importantly, stereotyped activities in the process models allow one to drive attention to focal perspectives, such as activities being performed solely on the Web, in presence phases, or serving quality assurance. The integration of the latter, in particular, has opened up a new dimension, namely the explicit consideration and consequent improvement of the quality of learning processes as integral constituents of these same processes. Means such as transparent online reaction sheets or online questionnaires have proved to be simple yet effective and feed into our participatory action research initiative that is sketched in Figure 2 (Motschnig-Pitrik, 2004).

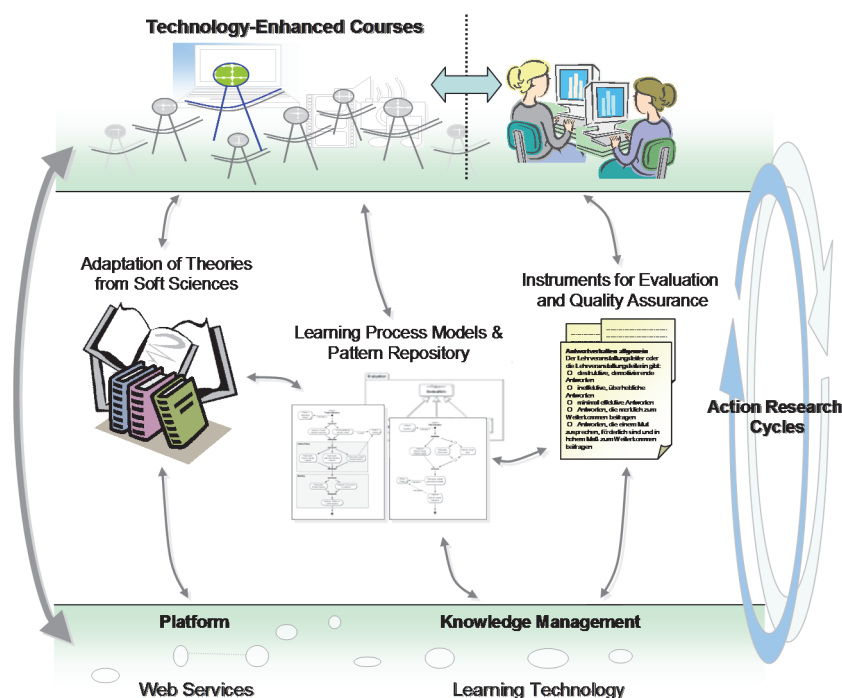


Figure 2: Ongoing research cycles tracking the quality of PCeL courses.

## EVALUATION OF THE COURSE AND ITS CONSEQUENCES FOR THE WORKPLACE – THE RESULTS

**Questionnaires on profitable aspects.** Since we were interested to find out from which aspects of the course students benefited most, an online questionnaire with 24 features was put online (compare Figure 3) and students were asked to indicate to what degree they benefited from each of the aspects. On a scale from 1 meaning “not at all” to

5 standing for “very much” the top six features in the course on Communication and Soft Skills and their average values were:

- Practical exercises during the lab hours (4.79)
- Active participation during the course (4.64)
- Exchange and discussion with colleagues (4.62)
- Cooperation with peers in teams (4.36)
- Exchange and discussion with the instructor (4.29)
- Considering situations from different points of view (4.21)

Interestingly, students felt they learned most from their active engagement: This encompassed practical exercises, whereby all of them (except for an initial exercise on active listening and one on team work) were suggested by the student teams in a self-initiated manner. Active engagement equally encompassed other forms of activities, in particular communicative exchanges that were emphasized throughout the course, both face to face as well as online. As the course was designed and facilitated in a way to promote, in particular, sharing and discussion among students as well as between students and the facilitator, the questionnaire results can be seen as a confirmation of meeting the course goals. It also illustrates that academic, person centered courses have the potential to meet, to a perceivable degree and significantly more than conventional courses (“typical courses”), learning goals that concern interpersonal skills.

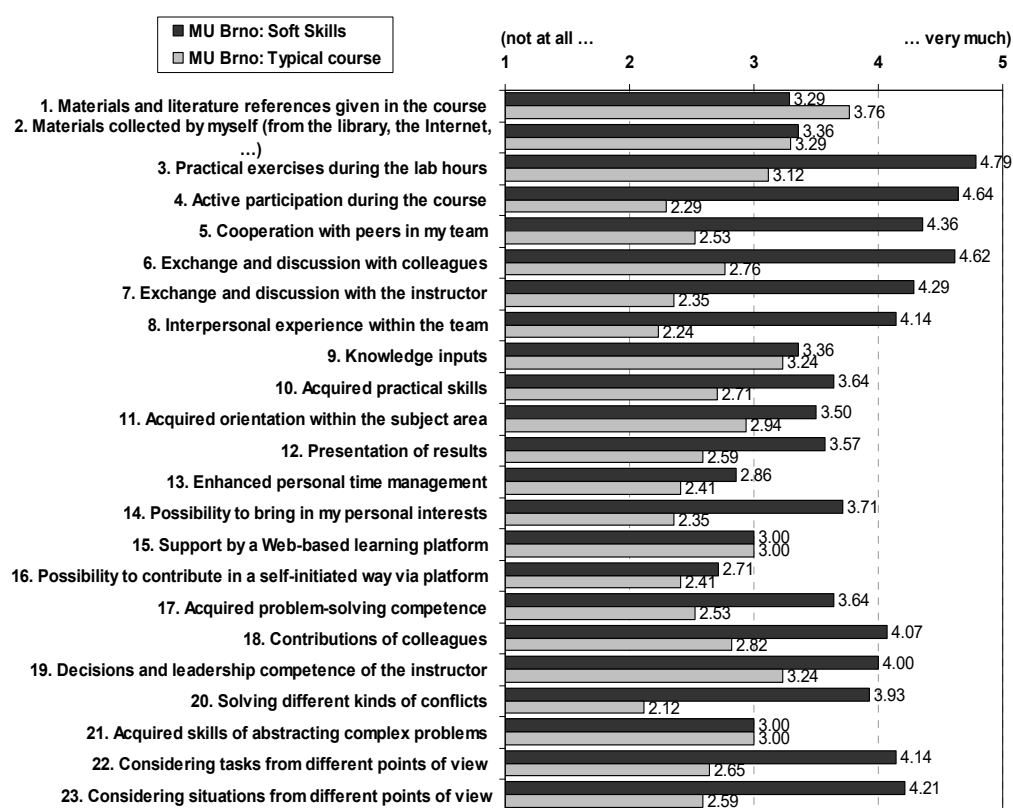


Figure 3: Students' ratings on profitable aspects in Communication and Soft Skills when compared with other courses in their studies. Scales from 1.. 'not at all' to 5 .. 'very much'; n = 14 (from N = 19 participants) (Motschnig-Pitrik, 2010).

The majority of students also indicated that they benefited much from “considering situations from different perspectives”. This result appears to be particularly important in international contexts, in which the teams tend to be composed of intercultural members whose typically different views and attitudes need to be considered and reconciled (Motschnig-Pitrik, 2015). The high rating in this aspect (and the related aspect of considering tasks from different points of view) also points to the assumption that student may have grown with respect to openness to other's views and respect towards others, although this tendency is more implicit and needs to be considered along with the written reaction sheets appear to point in the same direction. Further research, such as follow up interviews and/or content analyses of the students' reactions is needed to confirm or discard this hypothesis.

**Reaction sheets.** A formative kind of course evaluation was conducted after each block. Students were invited to submit online reaction sheet on any aspect of the course. The reactions were made available to be read by every participant about one week after each block. They also allowed the facilitator to address issues that had been raised in the reaction sheets in the follow up course block. That encouraged students to ‘raise their voices’. The online communication furthermore gave the more quiet students equal chances of expressing their views. In the following we share illustrative excerpts from students' reactions after each of the three blocks of course instances (in 2009 and 2015) held at the Masaryk University (Motschnig-Pitrik, 2010).

### **1st block (consisting of three 4-hour course units moderated by the instructor)**

A student shared his perceptions about the “new” educational model as follows: “This style of education embraced me by its informal and pleasant atmosphere – I think that the faculty of computer science would profit from running more of such courses, because currently the situation is such that students are required to cooperate in increasingly more subjects [...] but the number of subjects in which they can have topical discussions under professional guidance is minimal, if at all existent. I consider it an interesting idea to let students arrive at various results solely on the basis of exercises or discussions among themselves – the lived experience can be remembered better than an experience that is just learned from a book. [...] Furthermore, I see another benefit in the increased self-organization of students who participate in the course as well as improved communicative competencies, supposedly also a higher degree of tolerance toward different opinions. I do not claim that this educational model is the best possible, but it definitely means a benefit for me under the current circumstances at the faculty.”

### **2nd block (consisting of three 4-hour course units moderated by student teams)**

A student wrote: “The presentations of both teams left a deep impression on me, most enjoyable were the diverse exercises and discussions. The unit on conflict was highly instructive for me, in some directions it opened my eyes. Now I can better understand my behavior and that of my surroundings and I try to apply the newly acquired knowledge in my private life. It works but it is hard. It was interesting to watch the differences between characters and behavior, this time the differences were already more distinct, perhaps

because we know each other better. I am pleased by the general honesty in discussions and enthusiasm regarding work, I left with an optimistic mindset.”

Another student (from the course instance in 2015) reflected: “The course itself has really made a great impression on me. I think the way the course is taught is really optimized. [...] The fact that we as students have an opportunity to moderate a two and a half long unit is very helpful and valuable. The student-centered approach of the course is really what helps us improve ourselves in communication and soft-skills. On the other hand, we are not put into the action without any previous knowledge which has been introduced in the first unit. Another thing which really helps the course to be such effective is the openness and honesty that makes a friendly atmosphere, better discussions, better self-improvement and makes us looking forward to another unit.”

### **3rd block (consisting of three 4-hour course units moderated by student teams)**

The following excerpt characterizes the effects of a person-centered atmosphere very accurately: “I very much liked the mode/spirit of the group discussions. Sometimes it happened that discussions regarding a topic somehow unfolded themselves freely, this means without a call for a discussion, and besides the participants who always took part an ever increasing amount of participants joined in, even those who used to be more “tacit” group members before. [...] So far I have not “endowed” all the impressions and thoughts. During the course I personally got to know some new fellow students which I appreciate very much, because there have not been many such occasions during my studies so far. Another thing that I learned was not to be scared of speaking and not to be scared of being confronted with a different opinion. This, equally, is a major gain for me. [...] One does not only learn something (even if one does not realize that consciously in the first moments), but there is also brought into education some “human” dimension. Have more of that ...”

Another student emphasized the digital media provisions in the PCeL course: “I also appreciate that there are almost all the materials used available on the website, so we can look at them later when we need them. Another thing I like is that we can see the results of other people's reactions, but only after all the reactions are written, because we can see not only a feedback on our moderation unit, but also what other thinks about the course itself, etc. Just to sum up, I really enjoyed the course and I feel like it was very beneficial for me and I am taking a lot of information to my professional or personal life.”

An international student arrived at seeing himself somewhat differently: “In overall, I think this course was the biggest surprise that I had in here (in academic terms) because made me more rich in Communication and Soft Skills but also because it made me realize that I had some good skills to be a good manager and to lead in the future. I was in doubt about that.”

The above excerpts of students' reactions are intended to illustrate the truly experiential nature of learning and the way, students perceived the various elements of experiential learning listed in the previous section being put to practice. In the authors' view, the qualitative reactions provide more information about the course than the quantitative questionnaires. This is in part why we stopped applying the pre- post-study questionnaires.



## Students' Assessment from Their Internship in a Company for an Interim Project

The Master study program Service Science, Management, and Engineering (SSME) was introduced at Masaryk University almost a decade ago. As an important part of their studies, students of the program are required to do an *Interim Project* which is based on a supervised, goal-oriented stay in a company for 5 months. Usually, it is scheduled in the mid-part of the study, so that students can reflect their experience from Interims in further study and in writing their Master Theses.

Usually, the Interims provide an opportunity for a deep reflection of the knowledge and skills gained during the study and their applicability in real professional life. This reflection is a part of their reports where they summarize their experience. In 2011, the experience from the Interims was collected in a questionnaire form. Among other questions, the students of the SSME program were asked a question related to particular courses of the program: *Knowledge of which SSME course have you used during your Interim Project?* The answers were distributed as follows (see Table 2).

Table 2: Knowledge of which SSME course have you used during your Interim Project?

Course	Number of responses	Percentage
PA116 Domain understanding and modeling	1	3.4 %
PA179 Project management and Service Lifecycle	5	17.2 %
PV206 Communication and Soft Skills	9	31 %
PV098 Management of IS implementation	4	13.8 %
PV207 Business process management	1	3.4 %
PA104 Team Project Leadership	4	13.8 %
PV165 Process Management	1	3.4 %
PV209 Person Centered Communication	1	3.4 %
PA181 Services - Systems, Modeling and Execution	2	7 %
PV231 Integrated Marketing Communications	1	3.4 %

Thus, the courses directly applying Person-centered Communication (PV206 and PV209) were considered to have significant impact on the Interim. Similarly, when providing feedback in a narrative form, the students also frequently tackle the need of soft-skills and its importance:

One participant reports: "Throughout the Interim, I frequently used the knowledge gained in the subjects of SSME, especially soft skills, time management and more. I also tried to inspire and build my imaginary pyramid, the working culture of your company's

future. I used presentation and negotiating skills at the time of the initial interview. Interpersonal communication is needed, whether at work or elsewhere....”

Another student writes: “What I like most at SSME is a relatively wide choice of courses I could study. Therefore I studied what really interests me and moves forward. I used soft skills during the presentation of the project, when I was lecturing in front of an auditorium full of policemen and I took praise from all sides. In this together really I see much progress, because I'm a quite strongly introvert. The courses on management and soft skills helped me most in this respect.”

Students appreciate the open atmosphere in the person-centered soft-skills course and mention the missing skills which the course helped to gain. The course works as a mutual exchange of experience where also the teachers appreciate the positive feedback they receive for their endeavor. One of them noticed that “I like teaching the Soft Skills course very much. It allows me to meet new people and learn from their experience. I am pleased that students evaluate it positively and actively participate in the learning process. The course is reigned by positive and constructive mood that always charges me with new energy.”

## **DISCUSSION AND CONCLUSIONS**

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The person-centered technology enhanced course on communication and soft skills confirmed that experiential, or whole-person learning can be achieved in academic contexts, if we judge from the students' statements and the survey conducted during students' placement/”practicum” in an industry context. The course further confirmed that computer science students consider it meaningful and decidedly worthwhile to sharpen their soft competencies in a cooperative, active setting, accompanied by an easy to use open source e-learning environment.

Person-centered, technology enhanced learning aims at providing deep learning experiences to students on the basis of sensitively integrating web-technology into the Person-Centered Approach to education (Motschnig-Pitrik, 2013). Person-centered education is consistent with the constructivist orientation, however it emphasizes the importance of the interpersonal relationship of the instructor/facilitator and students. Besides being competent and knowledgeable in the subject matter, a person-centered facilitator is capable of providing a constructive learning climate in which students, first of all, feel respected and deeply understood (Motschnig-Pitrik and Rohlíková, 2012) Moreover, students are expected to endeavor to solve real problems that they consider worthwhile, based on the stance they take in their lives.

The general, the positive course experience from the sample course described in this article also indicates that claims from industry regarding improved competencies in (inter)personal or soft issues perfectly match the students' perception on what areas they feel they wish to learn/grow. We conclude that universities would be well advised to listen to these voices yet more intensely and devote more attention and budget to innovative learning/teaching styles made possible by new media in combination with interpersonally competent staff. Digital media and its application is clearly visible and in the foreground, having conquered its position in academic education. Staff development in the direction of facilitation and working with groups, however, appears to remain hidden in the shadow of

technological advances and, in our view, needs to be strengthened in order to be able to pass on advanced (inter-)personal skills to our students and thus enable their becoming more competent, effective and satisfied individuals and team mates.

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# Smart Learning Environments Revisited

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## Abstract

*Recently, a big effort focused on research in the smart environments for learning area already resulted in a number of interesting projects and results. Smart environments for learning, based on approaches and technologies deployed in related areas of Ambient Intelligence and Smart Environments, certainly deserve considerable attention of the large community oriented on technology enhanced learning. Smart environments for learning can be naturally considered a new challenging step of computer enhanced learning evolution, with many new interesting facilities. As multi-agent systems are the most frequently used approach towards smart environments design in general, a systematic approach towards reflecting all desirable functionalities of smart learning environments should be based on a well-designed multiagent architecture. Moreover, a number of new technologies and approaches influenced recent research in the area of smart learning environments. Let us mention cloud –based architectures and applications as a representative.*

*This contribution tries to summarize recent state of the art in the area, stressing the main features of successfully implemented projects. A couple of unsolved problems will be presented, together with a vision of possible future evolvement of smart learning environments.*

## Keywords

*Computers and education. Ubiquitous computing. Ambient intelligence. Smart environments. Multi-agent systems.*

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## INTRODUCTION

A few years ago, in our paper (Mikulecky, 2012), we tried to map the state of the art at that time in the area of ubiquitous and context aware learning (smart learning) in a special type of smart environments, restricted on the case of smart workplaces. However, the paper, based on our research from those years, has also another benefit, which we witnessed up to now. Taking into account a number of references on it, the paper was also a good contribution towards the area of smart learning environments as a dynamically evolving and modern field, or better to say, a new phase in technology supported learning. However, after a couple of years from the time of the paper's origin it is necessary to revise many ideas from that epoch. This paper is something like an upgrade of our state of the art view on the area of smart learning environments.

In (Winters, Walker, Rousos, 2005), a smart environment for learning is defined as any space where ubiquitous technology informs the learning process in an unobtrusive, social or collaborative manner. It means, that a smart environment can be an 'aware' room or building, capable of understanding something about the context of its inhabitants or workers; it can be a digitally enhanced outdoor space – park, cityscape or rural environment; or it can be the environment created when peoples' meetings or interactions are augmented by wearable devices, as Alsaif (Alsaif, 2014) pointed out. These ideas are very close to that of original ISTAG Scenario 4 (Ducatel et al., 2001) *Annette and Solomon in the Ambient for Social Learning* (ASL).

The ISTAG Scenario 4 was a vision of a learning environment, based on a position that learning is a social process. The scenario certainly was a nice incentive for a number of new initiatives focused on more or less successful attempts to design and introduce various types of smart environments capable to support different aspects of learning process. We tried, in our paper (Mikulecky, 2014) proposing of a new multiagent architecture aiming at achievement of the "ideal" architecture inspired by the ISTAG Report. However, our architecture proposal was just a conceptual suggestion of a possible multi-agent architecture for the ASL, still without further practical implementation.

Discussing the importance of the ISTAG Annette and Solomon scenario, Alsaif (Alsaif, 2014) stressed, that if we took into account the ISTAG scenario that could serve as an ideal case for a smart learning environment, the popular view of "anywhere and anytime learning" should be considered as impractically broad. According to that, the challenge in the information-rich world is not to provide information at any time and at anywhere, but to say *the right thing at the right time in the right way to the right person* (Hwang, 2014). More related ideas and standpoints can be found, e.g., in (Bures et al, 2016), (Mikulecky, 2011, 2012b, 2013, or 2014), and in (Mikulecky, Olsevicova, Cimler, 2012).

There are a number of attempts to specify and to create such learning environments that we can call smart learning environments. In the next chapter, we try to review some interesting improvements in this direction.

## SMART LEARNING ENVIRONMENTS SPECIFICATIONS

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According to (Kinshuk, 2014), *"a learning environment can be considered smart when the learner is supported through the use of adaptive and innovative technologies from childhood all the way through formal education, and continued during work and adult life where non-formal and informal learning approaches become primary means for learning"*. That is, Kinshuk supports the meaning of smart learning environments as neither pure technology-based systems nor a particular pedagogical approach, but a subtle mixture of both.

The context aware and ubiquitous learning as being naturally close to the educational perspective of Ambient Intelligence as well as to the idea of smart learning environments, was defined and studied by many authors. In one of our previous papers (Mikulecky, 2012) we pointed out that ubiquitous computing has tremendous potential for framing learning, particularly in informal and socially constructed contexts. To reach this potential it is necessary designing, developing, and testing of

new ubiquitous prototypes for learning systems. A more general overview of the Aml possibilities in education brings our recently published paper (Bures et al., 2016). Its aim is to present selected ideas supporting the vision of smart environments for higher education in the Czech university settings.

(Libbrecht, Müller, Rebholz, 2015) understand Smart Learning Environments *“as systems that apply novel approaches and methods on the levels of learning design and instruction, learning management and organization, and technology to create a context for learning that provides learners with opportunities for individualized learning and reflection in a motivating way, and that allow teachers to facilitate learning, providing scaffolding and inspiration based on the learner’s needs and a careful observation of her learning activities”*. As a conclusion, they pointed out that approaches in the direction of Smart Learning Environments cannot be restricted only on the technological level.

Hwang (Hwang, 2014) presented the opinion that although context-aware ubiquitous learning seems to provide a promising form of learning, it is still far from ideal technology-enhanced learning, which deserves the name *“smart learning”*. According to Hwang, *“a smart learning environment not only enables learners to access digital resources and interact with learning systems in any place and at any time, but also actively provides the necessary learning guidance, hints, supportive tools or learning suggestions to them in the right place, at the right time and in the right form”*. The features just mentioned should be essential for smart learning environment. A smart learning system can be perceived as a technology-enhanced learning system that is capable of advising learners to learn in the real world with access to the digital world resources. A smart learning environment aims to help students gain knowledge even when they are doing leisure activities. Hwang concludes that a simple incorporation of an intelligent tutoring system into a context-aware ubiquitous learning environment is not enough for obtaining a real smart learning environment.

Further, Hwang (Hwang, 2014) summarized the potential criteria of a smart learning environment as follows:

- (1) A smart learning environment is context-aware; that is, the learner’s contexts in the real-world environment are taken into account by the smart learning environment, therefore the system is able to provide learning support based on the learner’s online and real-world status.
- (2) A smart learning environment is able to offer instant and adaptive support to learners by immediate analyses of their needs from different perspectives (e.g., learning performance, learning behaviours, profiles, personal factors) as well as contexts in which they are situated. Moreover, it can actively provide various personalized support to the learners, including learning guidance, feedback, hints and learning tools, based on their needs.
- (3) A smart learning environment is able to adapt the user interface and the subject contents to meet the personal factors (e.g., learning styles and preferences) and learning status (e.g., learning performance) of individual learners. Learners can interact with the learning environment also via mobile devices (e.g., smartphones or tablet computers), wearable devices (e.g., Google Glass or a



digital wristwatch), or even ubiquitous computing systems embedded in everyday objects.

It should be clear from the previous contemplations, that a smart learning environment has to be context-aware (that is, has to take into account real world state of the learner as well as his/her online states), it has to be adaptive and able of personalization in order to meet the personal needs of the learner, see also (Balogh, Koprdá, 2012).

## **SOME RECENT RESEARCH DIRECTIONS**

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In educational environments, the Ambient Intelligence (AmI) allows to follow the dynamics of teaching and learning of users, such as supervising the student performances, providing digital contents according to the student's learning style, or linking students studying similar topics, etc.

In a very recent paper (Kinshuk et al., 2016), the authors argue for a transformation from the current learning environments to smart learning environments. Their opinion is that smart learning environments go beyond simple application of technology. Smart learning environments *"enable the fusion of technology and pedagogy to create an ecosystem that involves active participation of teachers, parents and others in the learners' learning process. They also provide real-time and ongoing evidence of changes in knowledge, instilling skills, which are seamlessly transferred to learners as they move from one learning context to another"*. As Kinshuk and his colleagues emphasized, *"due to rapid advances of information and communication technology (ICT) in recent years, learning technologies have already affected and changed the educational landscape significantly. In order to provide learners with a learning environment that makes effective use of technological advances, teaching methodologies and learning strategies also require changes. For example, cyber synchronous learning, mobile learning, social learning, and ubiquitous learning did not exist in the past educational landscape. Therefore, new teaching methodologies and learning strategies are desperately needed in the current education systems to support these newly emerging modes"*. Kinshuk (Kinshuk et al, 2016) concludes that smart learning environments engage and integrate formal and informal learning in order to create autonomous adaptive learning environments for supporting individual learners with real-time and seamless learning experiences in ubiquitous settings. Different formulation, but nearly with same meaning, can be found in (Hwang, 2014) two years ago: *"a smart learning environment not only enables learners to access digital resources and interact with learning systems in any place and at any time, but also actively provides the necessary learning guidance, hints, supportive tools or learning suggestions...in the right place,...right time and... right form"*.

There are three major features of the development of smart learning environments that separates smart learning environments from other advances in learning technologies. The three features/directions are full context awareness, big data and learning analytics, and autonomous decision-making [Kinshuk et al, 2016].

Full context awareness enables smart learning environments to provide learners with authentic learning contexts and seamless learning experiences to fuse a variety of features in the e-learning environments. The system includes learning management systems,

mobile and ubiquitous learning systems, various artificial intelligence based adaptive and intelligent tutoring/learning systems. These systems would assist teachers and instructors in direct monitoring of the learning environment, understand learners' conditions and give learners real-time adaptive assistance, while at the same time facilitating independent learning for the learners (cf. (Kinshuk et al., 2016) or (Hwang, 2014)).

Smart learning environments are expected to facilitate smart learning support that is based on each individual learning profiles. Smart learning environments need to consider advanced data manipulation techniques such as employing big data and learning analytics to collect, combine and analyse individual learning profiles (from past to present) in order to scientifically generalize and infer each individual learning need in real time in ubiquitous settings that encompass both physical and online activities. Learning analytics by using big data can monitor individual learners' progress and behaviour continuously in order to explore factors that may influence learning efficiency and effectiveness (Kinshuk et al, 2016). Kinshuk also stressed that through big data and learning analytics, smart learning environments could derive new and more effective learning models by analysing the data collections of various learners and further extract valuable learning patterns, to provide suggestions and recommendations to the learners over long periods of time, possibly even during their future careers.

Another important feature of smart learning environments, which is different from other learning environments, is their autonomous knowledge management capability that enables them automatic collection of individual learners' life learning profiles. For smart learning environments possessing an autonomous decision-making capability that could utilize learning analytics features to provide individual adaptive learning support, is important. As Spector points out, it is necessary for a smart learning environment to autonomously provide *"different learning situations and circumstances, as... a human teacher or tutor...to help learners become more organized and aware of their own learning goals, processes and outcomes"* (Spector, 2014). In a relation to this, it is worth to mention initiatives focused on learning analytics, as computer-based learning tools provide the benefit that all sorts of digitally available learning data can be collected and analysed. For instance, Boulanger and his colleagues (Boulanger et al., 2015) presented a mixed-initiative learning analytics framework SCALE aimed at collecting learning traces from any learning domain and analysing those learning traces to extract the underlying competency levels in the same learning domain. The SCALE framework has been designed for a full integration with a learning management system to make sensed learning traces reliable and associable to learning outcomes. In the future, SCALE would also incorporate a Causal Learning Analytics extension to determine the causes of various learning-related occurrences. This should include also identifying the causes of the successes and failures in learning outcomes and determining the impact that those factors have on the learning outcomes, promised Boulanger with colleagues in (Boulanger et al., 2015).

According to (Libbrecht, Müller, Rebholz, 2015), learning analytics can be related to approaches and technologies targeted to allow for analytical reasoning facilitated by visual interfaces employed for teaching or learning. They formulate its objectives as the detection of interesting aspects and patterns in learner and learning data, building hypotheses based on these detected structures, confirming such hypotheses, drawing conclusions, and possibly communicating the results of this analytical process.

The big data technology goes recently hand in hand with a broad utilization of cloud technology. This, recently very popular and useful technology can be very much suitable for the area of smart learning, and can be utilized as supporting technology for smart learning environments. As Sánchez et al. (Sánchez et al, 2016]) pointed out, cloud learning (C-Learning) allows to reuse learning resources in a distributed manner. CLearning provides available educational services in the cloud, using the mechanisms and tools that provides cloud computing. In particular, the Aml for education based on the cloud could be used as a space, where the technologies of the cloud and ubiquitous, help the learning processes in an unobtrusive manner, to improve their scalability and integration capabilities, pointed out Sánchez and his colleagues.

A good example of cloud technology utilization for smart learning can be found in (Akaichi, Saidi, 2012). The authors proposed an assistance system, based on pervasive cloud solution, for lifelong mobile learners, namely for mobile professionals motivated to improve their skills through a lifelong learning process. The solution was performed by using a number of Software as a Service approaches. These were oriented on such activities as learning centres localization, learning centres courses matching with mobile professional curriculum and level, learning centres courses schedules matching with mobile professional free time, and mobile professional subscription according to learning centres vacancies. All of these activities generate data, which are then integrated into a data warehouse and analysed according decision makers' needs.

Another great challenge in the area of Aml is the research of Smart Classrooms for education. Aml naturally brings new ideas and approaches into educational process at every level of education, therefore redefining a classroom is an inevitable trend, where sensor technology, communication technology, artificial intelligence, etc. are integrated into a classroom. The idea is to exploit the smart environments in an educational process, considering the specific aspects on the educational domain (present and virtual education, self-formation, etc.) and the advances in ubiquitous computing, augmented reality, mobile computing, etc. (Aguilar et al., 2015) contributed recently to the area of smart classrooms in that they define a Smart Classroom based on the multiagents paradigm. They call this classroom SaCI as an abbreviation for Spanish "*Salón de Clase Inteligente*". They defined different components in a Smart Classroom and proposed two types of agents (frameworks), one to characterize the software components and the other to define the hardware components on this environment. Additionally, they tested the capabilities of description of proposed frameworks. Some more recent information from the same research group can be found, e.g., in (Aguillar et al., 2016), or (Sánchez et al., 2016), where also some further results on cloud utilization for smart learning environments are described.

In another recent paper about smart classrooms, Oluwagbemi and others (Olubagwemi et al., 2014) provide a review on different pervasive technologies applications to classroom environments and the benefits they caused. They stressed that future trends of pervasive computing technology that will be applied within classroom environments in the next two to three years include: 3D printing technologies, games and gamification, virtual assistants and quantified self, as a technology that helps to monitor daily human activities.

Last, but not least direction of research of smart learning environments area should be devoted to smart cities. In the paper (Buchem, Pérez-Sanaugustín, 2013), the role of

smart cities as living labs for market, public, social and cultural innovations is emphasized. Smart cities can be also viewed as smart learning environments, i.e. environments which exploit new technologies and approaches, such as ubiquitous and mobile learning, to support people in their daily lives in a proactive yet unobtrusive way (Mikulecky, 2012). In this sense, smart cities as smart learning environments utilize the idea of ambient intelligence by integrating diverse computation, information and communication resources into a united framework of an ambient intelligent space. Buchem and Pérez-Sanaugustín (2013) tried to understand how Personal Learning Environments might be constructed as part of smart city learning. Based on the preliminary results of their international, explorative study, it was possible to identify three key generic strategies for constructing Personal Learning Environments in context of smart city learning. These include constructing Personal Learning Environments by interacting with people, objects and tools. To support learners in constructing their Personal Learning Environments in context of smart city learning, we need to understand what pedagogical strategies and technological uses could be most effective to do so. Nevertheless, this needs still an intensive research.

## CONCLUSION

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Smart Learning Environments are an attractive as well as modern area, with a lot of challenging problems, which need to be objects of further research. If we take into account the progress in the area, maybe the most important results are those, where the really “ideal” smart learning environment requirements are defined. The most valuable seems to be work by Hwang (Hwang, 2014), but also a bit older paper (Hwang et al., 2008). Recently a big contribution to the area can be found in Kinshuk’s papers (Kinshuk, 2014) and (Kinshuk et al., 2016). Particularly the last paper represents a fundamental contribution, which can be used as a very suitable source for people from the area of smart learning environments.

Undoubtedly, the area of smart learning environments has proven already its usefulness as well as usability. As (Turcani, Magdin, 2014) stressed in their paper, easier we accept information in a pleasant environment and form. This opinion is of great concern also in the case of smart learning environments. When both student and teacher have to do with a smart learning environment, supporting their teaching as well as learning processes, they certainly will be much more motivated for their work, they will really love working in such an environment.

There is already several representatives of this approach in the form of smart classrooms, there is also a number of interesting papers about practical experience with the approach in various applications, see e.g., (Klimova, 2015) or (Klimova, Simonova, 2015) as good examples.

We believe that there is an interesting future of smart learning environments ahead. As Abersek pointed out in (Abersek, Abersek, 2012), *“the teacher can with the help of information technology, through networking, with knowledge-based systems and experience based systems, artificial intelligence systems, act as a facilitator instead of merely a one-way communicator”*. However, a good human teacher role seems to be essential also when a smart learning environment is used. Nevertheless, together with a

true smart learning environment such a teacher could be even better. Perhaps it needs not to be the “ideal” environment; a smart one would be enough.

## ACKNOWLEDGEMENT

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The research has been partially supported by the Czech Scientific Foundation project No. 15-11724S *DEPIES - Decision Processes in Intelligent Environments*.

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## **Conference Papers**

Section:

**Information Technologies Supporting Learning**

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# Modernization, Optimization and Development of STEM Education

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## **Abstract**

*The EU needs all its talents to boost creativity and competitiveness. It needs an innovative science education which shall enable today's and tomorrow's citizens to play a more active role in the research and innovation process, to make informed choices and to engage in a democratic, knowledge-based society. We would like to point out two sides of the problem of promotion and proper presentation of science and engineering knowledge and to encourage the young generations to pursue careers in science, technology, engineering and mathematics (STEM), namely: pedagogical problem (wrong methods of teaching science) - shift to innovative and effective methods in education is necessary in order to raise the attractiveness of science education and scientific careers and to boost the interest of young people in STEM, and technological problem (wrong methods of learning science, improper use of information communication technology) - we must strive for an approach aimed towards the students; moreover, the student and his/her experience needs to be placed in the center of the educational process. In the frame of presented concept in this paper, we will focus on innovative technologies for brain based learning and try to point out integration of different components into smart (intelligent) STEM learning environments for all technologies support composing, using and distributing interactive educational contents and service, with assessment of feedback functionalities, based on collecting and analysing of metadata. On the base of this analyses we should be capable to optimize whole learning environments, learning system and/or learning path.*

## **Keywords**

*STEM education. Intelligent tutoring systems. Transdisciplinary approach. Gamification. Ecosystem.*

## **INTRODUCTION**

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The EU needs all its talents to boost creativity and competitiveness. It needs an innovative science education which shall enable today's and tomorrow's citizens to play a more active role in the Research and Innovation process. It needs young boys and girls to pursue careers in science, technology, engineering and mathematics (STEM), while at the same time adhering to the values embedded in Responsible Research and Innovation. In such a manner, the Union will reach the objective of a R&D intensity of 3% of GDP which is essential. Yet it has been increasingly difficult to attract adequate numbers of young people, to these domains and to avoid a brain-drain of talent from Europe. Therefore, a

shift to innovative and effective methods is necessary, so as to raise the attractiveness of science education and scientific careers and boost the interest of young people in STEM (Aberšek, 2013, Kordigel Aberšek, Dolenc, Kovačič, 2015). We would like to point out in this paper two sides of the problem of promotion and proper presentation of science and engineering careers and to encourage the young generations to pursue careers in science, technology, engineering and mathematics (STEM), namely firstly pedagogical problem and secondly technological problem. Analyse shortly these two parts of the problem.

## **PEDAGOGICAL POINT OF VIEW**

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In the last decade many researches have been done in the field of education that have predicted the crucial changes in the educational systems. To state a few: Innovative learning: key elements for developing creative classrooms in Europe (Bocconi, Kampylis, in Punie, 2013), Education for all; Global monitoring report: Education for all by 2015, will we make it? (UNESCO, 2008), Creating effective teaching and learning environments: first results from TALIS (OECD, 2009), Understanding the Brain: The Birth of Learning Science (OECD, 2007), Bringing a 1-to-1 Program to Life (Microsoft Partners in Learning, 2010). And certainly a number of other researches: PISA, UNESCO, EU commissions, PIRLS, ICILS, TAUS, HBSC... All this research shows, that the space of general education is drastically changing and science, technology, Engineering and mathematics (STEM) even more. Changes require new paradigms and approaches to teaching especially while introducing new technologies. In the field of education many innovative shifts have been made, as mentioned at the beginning.

## **Technological**

Much has been said about the potential of new technologies to transform education and training, but only a handful of these statements have been supported by research or even tested by thorough scientific research (Lowe & Schnotz, 2008; Mayer, 2009; O'Neil & Perez, 2003, 2006; Pytlík Zillig, Bodvarsson, & Bruning, 2005; Reiser & Dempsey, 2007; Rouet, Levonen, & Biarreau, 2001). Learning with technology refers mostly to situations when technology is used with the purpose of encouraging learning. Today's term "learning with technology" mostly reflects what Lowyck (Lowyck, 2008, p. xiii) calls "a common impulse to (try to) use available technology for schooling purposes". At this stage we need to distinguish between two different directions: technology oriented (before 2000) and learning oriented (after 2000) approaches to teaching (Dumont, Istaitieh, & Benavides, 2010). In the technology oriented approach, the use of technology is in the centre of education, enabling access to the latest technology. On the other side, in the learning oriented approach, we must focus first on how people learn, and we perceive technology merely as an aid, as a tool for learning. Therefore, it seems that technology needs to be adapted to the needs of the students and teachers to create suitable methods for working with it and a suitable pedagogical approach (Aberšek, Borstner, & Bregant, 2014). In short, the majority of yesterday's optimistic forecasts about the influence of educational technology on education have not come true. Taking into account these previous disappointments, in teaching using technology we must strive for an approach aimed towards the students; moreover, the student and his experience need to be placed at the centre of the educational process (Dumont et al., 2010).

One of the basic questions facing educators has always been: *Where do we begin in seeking to improve the teaching/learning process?* Undoubtedly, modern lessons are based on a modern learning environment. However, merely introducing modern ICT, such as intelligent tutoring system (ITS), is not enough. Additionally, we certainly need at least two elements in the process of education, if we disregard teacher's qualification, and these are as follows:

- Modern, innovative teaching and learning methods and a pedagogy that supports and guides the use of ICT (Bocconi, Kampylis, & Punie, 2013) and
- Modern learning materials (Course/subject curriculum), to give content to the ICT, and therefore function and concomitant its true value.
- Without mutual and integral interaction of all elements, improved results cannot be expected, because with an integral transdisciplinary approach we must do the following:
  - firstly, start from the question, how individuals learn; answers to this can be found in modern cognitive science and neuroscience (Mathews, Badia, & Verschure, 2010, Aberšek et al., 2014) and
  - secondly, establish how to implement these findings in the form of e-materials and teaching/learning environment (Kurilovas, Zilinskiene, & Dagiene, 2014; Ozyurt et al., 2013).

The general idea of the new proposed concepts supports a range of activities, which raise student's awareness and interest of the different aspects encompassing science and technology in their societal content and to address the challenges faced by young people when pursuing careers in STEM (Aberšek, Borstner, & Bregant, 2014).

Results will be to show how can young people work with open-access educational resources; become familiar with the use of science media; make the link between creativity and science; appreciate the relevance of gender balance and dimension in research; understand the practical value of research ethics and integrity and on the base of this be better and creative human been oriented in creation of better world through science, technology and engineering activities (Aberšek, Borstner, & Bregant, 2014b).

## **CONCEPT AND APPROACH**

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The new technologies made significant changes to education landscape generally and especially at STEM area and approaches to education are already having a clear and positive impact on education provision. Results of this are that the education landscape is undergoing significant changes. We are witnessing changes in the way education is taught and in the way students learn. While the conventional setting of the lecture hall will continue to form the bedrock of education systems, it will be enhanced by the integration of new tools and pedagogies, and it will be complemented by many more online learning opportunities and a greater variety of providers in education (Aberšek, Borstner, & Bregant, 2014b). The new technologies, knowledge's about this new technologies and approaches to education are already having a clear and positive impact on education provision (Bocconi, Kampylis, & Punie, 2013; Fletcher, 2003; OECD, 2009, 20013). New models of provision way of teaching/learning bring specific challenges.

## Development of new pedagogies

The report to UNESCO of the International Commission on Education for the Twenty-first Century, chaired by Jacques Delors, strongly emphasizes four pillars of a new kind of education: learning to know, learning to do, learning to live together with, and learning to be. In this context, the transdisciplinary approach can make an important contribution to the advent of this new type of education (*Treasure Within*, 1996, Flogie, Aberšek, 2015).

The new teaching paradigm should origin from the idea of *cognitive educator (human and/or virtual one)*: a cognitive educator is the educator who uses science of the mind as a tool at her modelling of the teaching and learning process. As with any area of science, educators have a set of problems that they are trying to solve and a set of phenomena that they are trying to model and explain. The global aim of this paradigm will be to make step in the connection of different disciplines involved in cognitive modelling in education built around philosophy of mind and cognitive science. The overall objective will be to explore an integrated approach to problems of connecting education with the contemporary knowledge from the area of philosophy of mind, cognitive science, psychology, neuroscience and artificial intelligence (Aberšek et al, 2014).

## RESEARCH AND DEVELOPMENT

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The basic system and content architecture of presented products and tools, learning ecosystem (LE) is developed as an intelligent, adaptive and individualised e-learning environment and build as modular system – a STEM eco system.

A cognitive transdisciplinary learning approach was taken as a foundation in creating the content of a pilot model of the learning environment and e-learning material which is an individualized, intelligent, student-oriented learning environment (Flogie, Aberšek, 2015). Some innovations and characteristics that distinguish it from other systems can be listed as follows:

- *The content is in accordance with the cognitive approach*: Content is prepared in such a way that it guides the user according to his or her current knowledge and current learning capacity. System is designed so that learning proceeds from easier to harder, from simple to complex.
- *Intelligence and adaptivity*: Because LE follows the user, it can, with the help of metadata, automatically adjust the difficulty of the learning content to the user. The user also has at his or her disposal a range of content and help, which can be chosen when needed.
- *System for collecting metadata and variables (SCAMV)*: Collecting metadata and variables allows direct analysis and evaluation within LE itself and outside of it. LE also allows the exporting and sending of metadata to developers and teachers, who can use the assembled data to evaluate the students and for “external” optimization of LE.

Architecture of the LE pilot system is built modularly; thus, a random part of the content can be changed and supplemented with new content or learning pathways and not interfere with the regular functioning of the whole system. A system that is built according to such a modularly structured principle allows more than a simple replacement

or substitution of individual modules but also permits vertical and horizontal interconnection of content within an individual curriculum and among separate curricula.

Whole system is presented in the figure 1. It is intelligent learning and teaching environments which can run at all platforms (Windows, IOS or Android) and at the all equipment's (notebooks, tablets or smart phones).

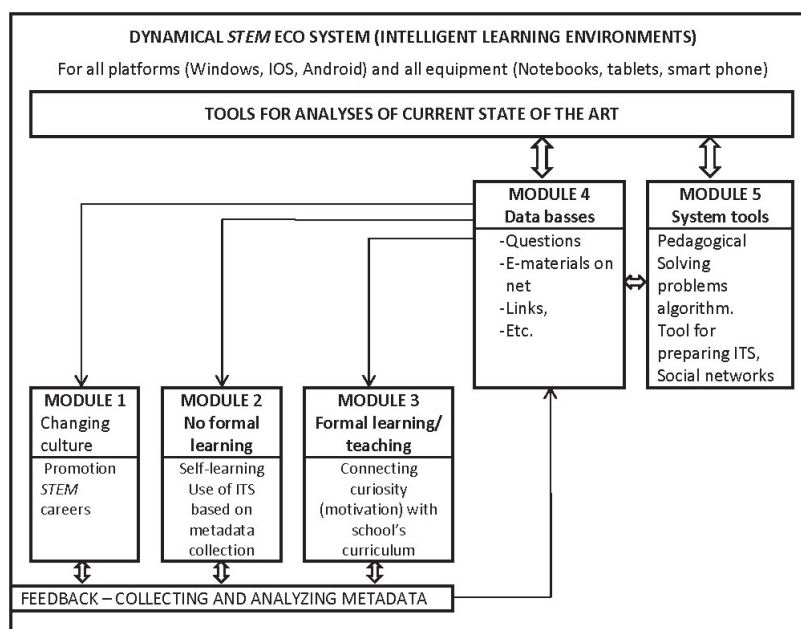


Figure 1: Concepts of teaching/learning Eco system

At this moment we are at the beginning of pilot phase. We will try to explain functioning of LE on the one part of it (Module 2), on the intelligent tutoring system (ITS) named TECH8 (Dolenc, Aberšek, 2015).

A cognitive learning approach was taken as a foundation in creating the content of a pilot model of the TECH8 e-learning material which is an individualized, intelligent, student-oriented learning environment. Some innovations and characteristics that distinguish it from other systems can be listed as follows:

- *The content is in accordance with the cognitive approach:* Content is prepared in such a way that it guides the user according to his or her current knowledge and current learning capacity. TECH8 is designed so that learning proceeds from easier to harder, from simple to complex.
- *Intelligence and adaptivity:* Because TECH8 follows the user, it can, with the help of metadata, automatically adjust the difficulty of the learning content to the user. The user also has at his or her disposal a range of content and help, which can be chosen when needed.
- *System for collecting metadata and variables (SCAMV):* Collecting metadata and variables allows direct analysis and evaluation within TECH8 itself and outside of it. TECH8 also allows the exporting and sending of metadata to developers and teachers, who can use the assembled data to evaluate the students and for “external” optimisation of TECH8, for example at the end of a school year. Figure

*Modular architecture of the system:* TECH8 is built modularly; thus, a random part of the content can be changed and supplemented with new content or learning pathways and not interfere with the regular functioning of the whole system (Fig. 2).

As seen in Figure 2, the learning whole represents the curriculum of a desired course. The learning whole consists of separate learning units, which include different content sections for an individual course.

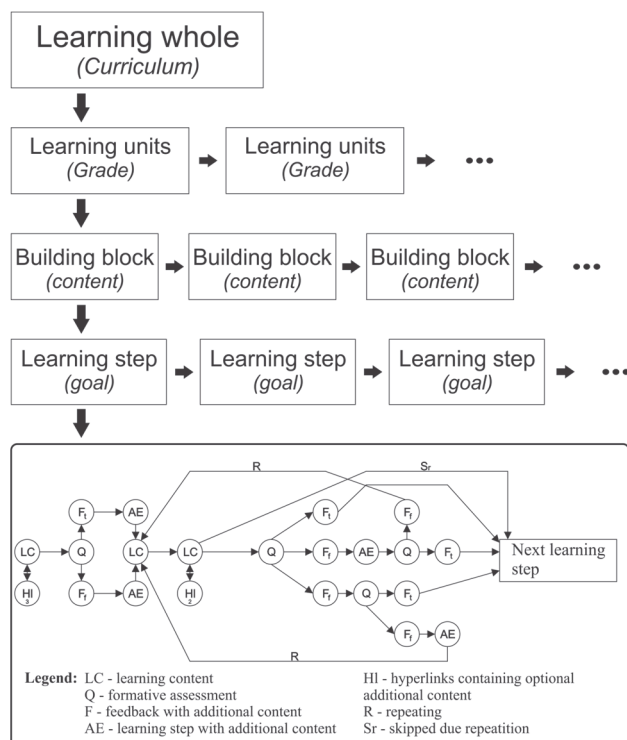


Figure 2: Basic architecture of a TECH8 intelligent tutoring modular system (Dolenc, Aberšek, 2015)

## RESULTS

The aim of the empirical research is the implementation, evaluation and optimisation of TECH8, which is based on adaptive and, most importantly, on individual e-learning with ITS. The research was divided into two steps:

- Preliminary research: testing and evaluation;
- Full scale research: optimization, implementation and re-evaluation.

Each school selected in the research participated with two classes arranged as follows:

- One class represented *the control group*, where conventional lessons were carried out (teacher, use of learning puzzles, sets of building blocks with gears, disassembly of several machines and examination of the gears)
- The second class represented *the experimental group*, in which students independently used TECH8 (independent work by students, the teacher as merely a spectator)

## **Data analysis**

Quantitative data in the experimental group was collected via the SCAMV system for collecting metadata and variables developed for evaluating students and for adapting and evaluating TECH8. SCAMV collected over 300 - 400 separate items of metadata per student. Quantitative data in the control group was collected, reviewed and rated by a group of experts in the field of technology and science. Quantitative data collected in the experimental and the control groups was analysed according to the following phases, or by: encoding, defining and organizing the data and interpreting the results.

Data from NAK was collected, evaluated and statistically processed by the national curriculum committee for the Technology and Science course and published in the yearly report of the National Assessment of Knowledge.

## **RESULTS AND DISCUSSION**

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The acquired results were analysed via descriptive statistical techniques. With the preliminary research, it was possible to successfully test TECH8's technical functioning. It was established that the SCAMV system functioned successfully and that it collected metadata. A problem was identified in the stability of the system that sends metadata. Because of the amount of data (300 – 400 items per student) certain data was lost that was intended for the evaluation of the content itself. The metadata and variables intended for adapting TECH8 to students functioned as intended.

In the full scale research, the main research question was the deviation between levels of knowledge in the TECH8 groups (students' individualised-learning) and traditional teaching groups.

The control group, composed of 58 students, achieved an average of 16.72 points in the summative assessment, which is 44.3%. The experimental group, composed of 59 students, achieved an average of 20.71 points in the summative assessment, which is 55.7%. The standard deviation in both groups is very high, which confirms that as with NAK there are great differences in the students' levels of knowledge. The skewness value for the experimental group is negative, which indicates that the mass of distribution is concentrated on the left. The skewness value for the control group is positive, which indicates that the mass of distribution is concentrated on the right. Skewness values for both groups indicate that, in the experimental group, the majority of students achieved better results, and that the majority of students in the control achieved worse results, as indicated in Figure 3 (Dolenc, Aberšek, 2015).



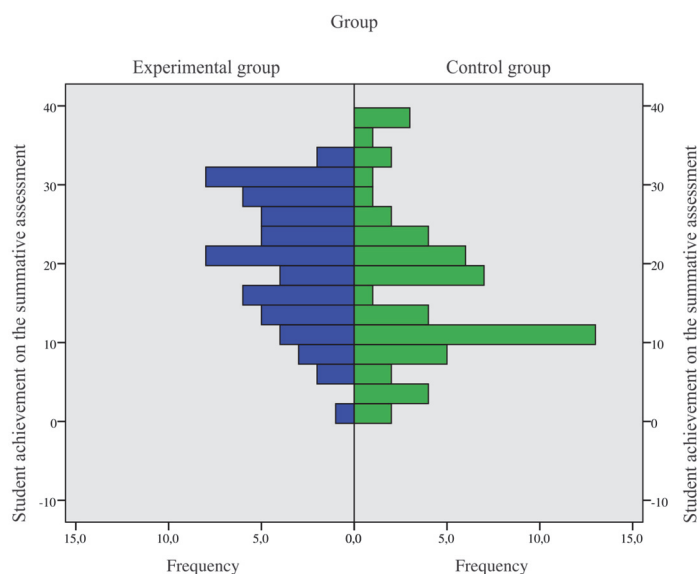


Figure 3: The frequency of results for the control and the experimental group (Dolenc, Aberšek, 2015)

The results of the experimental group with TECH8 were more than 10% better than those from the control group, which was to be expected. The progress of the experimental group in comparison to the control group is obvious from the cognitive level of students measured at the start of using TECH8 and the cognitive level achieved from the summative assessment at the end of using TECH8. The cognitive level represents the student's ability to comprehend and solve various tasks, especially those at a higher taxonomic level (Bloom, 1965). At the start of using TECH8, it was established that 30.5% of students fall within the lower cognitive level and 69.5% within the higher cognitive level. After the summative assessment and renewed classification, the percentage of students in the lower cognitive level was only 16.9%. The percentage of students who advanced to the higher cognitive level was 23.7%. 10.2% of students, however, regressed from the higher level to the lower. After a detailed analysis and evaluation of data acquired with the SCAMV system, it was established that all the students who regressed to a lower cognitive level were borderline cases, which means that the students' values measured at the start of using TECH8 were on the boundary line between the lower and higher cognitive levels but were classified in the higher cognitive level. 66.1% of students kept the same cognitive level as was measured at the start (Dolenc, Aberšek, 2015).

## CONCLUSION

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Our main ambition is to change philosophy of transferring knowledge on our educational system and to reach some positive social movements. Between all others we would like to increase the rate of adoption on technologies for modernization of education and training, facilitate the emergence of create a digital learning ecosystem in Europe, contribute to the objectives of the »Open up Education« initiative, and increasing the quality and efficiency of learning process (reaching higher cognitive levels of knowledge). Information-communication technology (ICT) is already an integral part of all school systems, while e-education and e-material are notions without which we cannot imagine schools today. This is why it is even more important that electronic learning material be

prepared in a high-quality manner and that it be intended for active education without the direct presence of a teacher or with only limited teacher input; moreover, it should not be perceived as an end in itself, as is often the case today. Modern research in educational processes shows that the highest educational goals cannot be achieved without the active participation of the student. In order to follow the appropriate development of the student's potential, it is therefore of the utmost importance that we continuously follow and evaluate the educational process, and implement corrections when needed. This way of working is largely enabled by modern (intelligent) electronic learning material, but only if it is correctly designed (from the viewpoint of pedagogy and didactics) and technologically implemented. Such material must also evaluate the user and in the case of poor results, change the path towards achieving the planned goals.

## **ACKNOWLEDGEMENT**

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This research supported by the project No. 2015-1-TR01-KA201-022247: *Intelligent Serious Games for Social and Cognitive Competence* under the Erasmus+ programme.

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# The Digital Natives Generation and their Prerequisites for Learning Online

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## **Abstract**

*The paper presents the results of a study, which examined science teachers' evaluation of online science learning literacy of the so called digital natives. According to the hypothesis that online learning competence is not immanent to the whole population due to being a complicated structure and demanding competence, the online learning competences of 3 groups of students were evaluated: the online learning competences of the general population at the age of 14, the online learning competences of gymnasium students, but also the vocational education students at the age between 15–18. The online learning competences were defined in terms of following aspects: basic skills (computer basics, web searching basics, general navigation basics), the ability of locating information, finding a suitable website, locating the information on the website, critical evaluation of the information according to its reliability and its relevance for the science class assessment. Data was collected through a 53-items Likert-scale questionnaire. The items were adopted from the TICA questionnaire for accessing students' general online reading competence. Science teachers accessed their students' online science literacy in order to evaluate their students' competence to use internet as a storage and source of knowledge for the teaching/learning process in the science class, to re-evaluate their online teaching practice and the need for implementation of natural science literacy of research and comprehension competence in their science curriculum.*

## **Keywords**

*Digital natives. Online learning competence. Science literacy of research and comprehension competence. ICT. Internet in science education.*

## **INTRODUCTION**

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UNESCO Institute for Information Technologies in Education in 2011 published a Policy Brief about digital natives – the way they learn and how to teach them. This, we name it didactical recommendation, relies on the fact, that »information and Communication technologies (ICT) have changed our society. Not only they provided us with new techniques and tools, they are also changing many core concepts and values. The relationship people have with technology is changing. New social behaviours are appearing: we collaborate with peers in new ways, we network with others. Knowledge is changing. Access to and acquisition of knowledge are changing and the ways in which we work with others are changing. In this digital society, a new generation has emerged: the

digital natives. (Cornu, 2011:1). The term digital natives' origins from the year 2001 and was introduced by M. Prensky (Prensky, 2001). According to his definition, digital natives represent »the first generation to grow up with this new technology. They are used to all kinds of digital toys and tools, which are an integral part of their life. Digital activity is like a mother tongue for them. They are the generation of technological acceleration, of the Internet and its networks. Growing up in such an environment they think and process information in a totally different way than previous generations. Their thinking patterns have changed, and Mark Prensky says it is likely that their brains have physically changed, too. They are "native speakers of the digital language" (Cornu, 2011: 3).

At first everything seemed clear and easy. Digital natives are native speakers of digital language. Therefore we cannot apply the education of yesterday to the pupils of tomorrow. Students have changed and pedagogy must find new ways to teach in ways that are appropriate for the new generation. Pedagogy has to be rethought taking into account the constructivist approach, collaborative learning and networking for learning. At this point nobody taught that maybe not all digital natives are prepared for the shift from the traditional to postmodern pedagogy. But slowly some voices were raised and claimed that the term digital natives would be dangerous. This implies the correlation with the language acquisition process: a person can learn the language in school or in a similar learning environment, can learn the language at the later age in the natural language environment or can be a native language speaker. Therefore, the language is its' first language – his so called mother tongue – or in recent time his L 1, his first language. In the terms of language acquisition the situation is clear, nobody speaks the language better than native language speakers. Native language speakers have nothing to learn from language teachers because language teachers are seldom native speakers. The majority of them have learned the language later, in school or at the university. The situation is similar in the context of digital literacy; if we accept the taught that the generation Z are digital natives, this would imply, they are, as being digital natives, digital superior to the teachers, who origin from previous generations and have become digital literate in other non-native environments.

This is a dangerous taught, since the current research guides to the revelation that for reading and learning in new digital environments users of online information sources and learning materials have to develop a new kind of literacy, the so called new literacy. Or to be more precise: new literacies are a demanding process, happening in stimulative environment. They do not occur by itself and therefor many digital natives need teachers' help and guidance.

### **Theoretical framework**

New school agendas all over the world recommend Internet "text" as a knowledge source and as source of information. Natural science didactics seem to be more open to the concept than social science didactics, which remains far more attached to traditional linear sources of knowledge. All that without considering the open question of prerequisite for such shift from page to screen and from linear to networked text structure – the new literacy of online research and comprehension.

Current (qualitative) research (Coiro, Dobler, 2007; Coiro, 2011; Leu et al., 2008) brought light in metacognitive processes and inferential reasoning processes expert e-readers are using by their successful reading of e-texts, explained what is the role of pre

knowledge in this process and why they contribute to better comprehension online. According to these findings the new literacy of online research and comprehension is structured and contains in the frame of each structural element skills, very similar to those, which are particularly useful in the process of linear reading, and additional complexities, needed for Internet comprehension. Based on this findings (Kordigel Aberšek et al. 2015) in later research Leu, Kinzer, et al. (2013) suggest that at least five processing practices occur during online research and comprehension: a) reading to define important questions, b) reading to locate online information, c) reading to critically evaluate online information, d) reading to synthesize online information and e) reading and writing to communicate online information.

Online reading comprehension always begins with a question or problem. This is an important source of the differences between online and offline reading comprehension. It is known that the new literacies of online reading comprehension occur within a process that includes the skills and strategies required to identify an important question directing the reader to locate, critically evaluate, synthesize, and communicate information with the Internet (Leu et al., 2008). Users read on the Internet to solve problems and answer questions. How a problem is framed or how a question is understood is a central aspect of online reading comprehension.

Locating information online is another aspect of online reading comprehension. It also requires new online reading comprehension skills such as using a search engine, reading search engine results or quickly reading a web page to locate the best link to the information that is required. Many students lack these skills. Of those who do use a search engine, for example, many do not appear to know how to read search engine results, instead clicking down the list of links in a "click and look" strategy (Leu, et. al., 2008). Locating information during the online reading comprehension process may create a bottleneck for the subsequent skills of online reading comprehension (Henry, 2007). Those, who possess the online reading comprehension skills necessary to locate information can continue to read and solve their problem. And those, who do not possess these skills cannot. In fact, this bottleneck may contribute to the lack of isomorphic performance between online and offline readers.

Another area in which online reading comprehension requires a unique set of skills is during critical evaluation. Whereas critical evaluation is important when reading offline information, it is perhaps more important online, where anyone can publish anything. Knowing the stance and bias of an author become paramount to comprehension and learning. Determining this in online contexts requires new comprehension skills and strategies.

Successful online research and comprehension also requires the ability to read and to synthesize online information from multiple online sources. Synthesis or integration of separate and unique ideas is recognized as the most demanding part of offline comprehension process. In reading on Internet it is even more demanding. The Internet introduces additional challenges for coordinating and synthesizing enormous amounts of information presented in multiple media from multiple media formats from nearly unlimited sources (Leu et al., 2014).

A final component of successful online research and comprehension is the ability of reading and writing to communicate online information via Internet, while interacting with others to seek more information or to share what you have learned (Leu et al., 2014).

Summing up all theoretical background we can repeat, what we already mentioned: expert readers use for reading on Internet a range of strategic cognitive processes to select, organize, connect and evaluate what they read. These strategies include asking questions, developing connections and making inferences, evaluating and synthesizing, what they have found, into a coherent knowledge about the topic and/or the research question (Kordigel Aberšek et al. 2015).

## **THE AIM OF THE STUDY**

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The central question of the study, performed in 2015, was, whether students at the end of compulsory and secondary education are competent for online research and comprehension and what is the level of their new natural science online research and comprehension literacy. Therefore, the study examined compulsory and secondary school natural science teachers' judgment of their students' online learning competence. Further the aim of the study was to find out the differences among the generation. According to this aim we compared not only the online learning competence between age of 14 (end of compulsory school) but also those from two groups of students at the age of 18: the gymnasium students and the students of vocational education school programs.

Four research questions were examined in this study: 1. How do natural science teachers judge their students' competence of online basic skills (computer basics, web searching basic, navigation basics)? 2. How do natural science teachers judge their students' competence for locating information by using a search engine? 3. How do natural science teachers judge their students' competence of navigation on web site? 4. How do natural science teachers judge their students' competence of evaluation of research results? The answers to these questions will reveal the answer to the central question of the research: are students, who all belong to a "Z generation", the so called "digital natives", online research and comprehension competent? Are they all prepared for total switch to online learning and to exclusively ICT supported natural science teaching paradigm?

## **METHODOLOGY OF RESEARCH**

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A sample comprised 59 natural science teachers, 16 of them were compulsory school teachers (who evaluated their students' online learning competence at the age of 14) and 43 upper secondary teachers – divided in two groups. The first group (22) were gymnasium teachers and the second one (21) were vocational education teachers. In Slovene school system compulsory school ends at the age of 14 (=9 years). After compulsory school almost the whole generation continues education on the secondary level. Half of the generation between ages of 15–18 attends a gymnasium education and the other the half the vocational education on different levels. The sample of natural science teachers included biology, chemistry, physics, mathematics and geography teachers, who were teaching on gymnasium.

Data was collected through a 53-item Likert-scale questionnaire. The items were adopted from TICA Checklist, developed in Teaching Internet Comprehension Skills to Adolescents project, which was focused in studying skills, essential to online reading comprehension (Leu et al., 2008). The original TICA checklist of online reading comprehension contained items from 5 areas, required during online reading comprehension: understanding and developing questions, locating information, critically evaluating information, synthesizing the information and communicating the information. The adoption, used for our research, focused on computer basics (Appendix A in original survey) and on locating information by using search engine (finding the useful web site), navigating on web site and evaluating the results of research (Appendix B in original survey). The number of items was reduced – in the checklist for computer basics from 29 to 21, in the checklist for locating information by using search engine from 26 to 15, in the checklist for navigating on web site from 8 to 7 and in the checklist evaluating the results of research (evaluation and reliability) from 16 to 10. The survey, used in this research, didn't contain questions about the competence for generating questions, synthesizing information and communicating information.

## RESULTS

Table 1 shows mean values of natural science teachers' and elementary teachers' evaluation of their students' online basic skills, which contains students' computer basic skills, their web searching basic skills and their general navigation basic skills.

Table: Check list 1 Online basic skills

1. Computer Basics	Age 14	VOC.	gimn.
Turn a computer on/off	4,80	4,81	4,95
Use the mouse/track pad	4,80	4,95	4,86
Follow classroom and school rules for computer use	4,19	4,62	4,45
Open programs and files using icons and/or the Start Menu (PC)	3,88	4,48	4,36
Create/open a new folder/file	4,12	4,52	4,68
Launch a word processor	4,25	4,81	4,77
Open a word processing file	4,12	4,76	4,77
Type a short entry in a word processing file	4,19	4,76	4,41
Copy text	4,31	4,67	4,73
Cut text	4,44	4,71	4,77
Past text	4,88	4,41	4,77
Name a word processing file and save it	4,63	4,76	4,77
Open a new window	4,25	4,81	4,73
Open a new tab	3,56	4,48	4,23
2. Web Searching Basics			
Locate and open a search engine	4,69	4,62	4,95
Type key words in the correct location of a search engine	4,69	4,53	4,82
Use the refresh button	3,71	4,38	4,50
Use the "BACK" and "FORWARD" buttons	4,38	4,57	4,82
3. General Navigation Basics			



Maximize/minimize windows	4,88	4.33	4,50
Open and quit applications	4,50	4.48	4,95
Toggle between windows	4,06	4.43	4,82

In general gymnasium natural science teachers expressed high evaluation of all 21 computer basic skills, listed on the cheque list for Computer basics. Only two items scored lower than 4,50: item "open programs and files using icons and/or the Start Menu (PC)" scored 4,36 and item "Open a new tab" scored 4,23. All other items scored between 4,50 and 4,95.

Natural science teachers, who were asked to evaluate the computer basic skills in students of vocational education, were not so confident in the existence of their students' computer basic skills. They scored their 'competence of opening programs and files' using icons and/or the Start Menu (PC)', the competence to 'past the text', the competence to 'open the new tab', the competence to 'minimize/maximize the windows', to 'open and quit application' and to 'toggle between the windows' lower than 4,50.

Table 2: Check list 2 Searching for a proper web site

	Age 14	VOC.	GIMN.
1. Locate at least one search engine.	4,88	4,62	4,77
2. Use several of the following general search engine strategies during key word entry:			
topic and focus	3,50	3,95	4,09
single and multiple key word entries	4,38	4,09	4,23
phrases for key word entry	3,50	3,86	4,09
3. Use several of the following more specialized search engine strategies during key word entry:			
quotation marks	2,63	2,95	3,41
paraphrases and synonyms	2,56	3,19	3,41
Boolean ( <i>and/or/nor</i> )	2,44	2,90	3,13
He can read search engine results effectively to determine the most useful resource for a task using strategies such as:			
knowing which portions of a search results page are sponsored, containing commercially placed links, and which are not.	3,06	3,47	3,86
skimming the main results before reading more narrowly	3,06	3,57	3,82
reading summaries carefully and inferring meaning in the search engine results page to determine the best possible site to visit	2,38	3,14	3,36
understanding the meaning of bold face terms in the results	2,94	3,71	3,55
understanding the meaning of URLs in search results (.com, .org, .edu, .net)	2,31	2,90	3,55
knowing when the first item is not the best item for a question	2,63	3,23	2,91
knowing how to use the history pull down menu	2,63	3,28	3,64
Bookmark a site and access it later.	2,63	2,90	3,23

The results of teachers' evaluation of the competence for location the information by searching for the proper web site, presented in Table 2, gives us some concerns, regarding the prerequisites for learning online and using web materials in this process. Upper secondary teachers, those who evaluated gymnasium students and those, who evaluated the vocational education students, expressed quite a great confidence in their students' competence to locate at least one search engine (M= 4,77 – gymnasium, M=4,62 – vocational education students), but observing the competence of using search engines

strategies and specialized search engine strategies, the differences between gymnasium and vocational education students is noticeable bigger.

The results in general search strategies (topic and focus, single and multiple key word entries, phrases for key word entry) and specialized search engine strategies (quotation marks, paraphrases and synonyms, Boolean) show that also many of gymnasium students' in their teachers' evaluation according to their teachers' opinion, couldn't use the specialized ones ( $M = 3,13 - 4,09$ ). The results are even more concerning at the vocational education students: only a little bit more than a half of them can be expected to use general search engine strategies ( $M = 3,86 - 4,09$ ), and less than half of them could use the specialized search engine strategies. At the end of compulsory school at the age of 14 specialized search engine strategies can be expected in the learning process of less than half of population ( $M = 2,44 - 2,63$ ).

The difference between gymnasium students, vocational education students and 3rd triennium students is bigger when we compare the competence of reading search engine results effectively. 3rd triennium students score between 2,31 and 3,06, vocational education students between 2,91 and 3,71, gymnasium students between 2,91 and 3,86. This means, that more than a half of gymnasium and vocational education students are competent of using 6 of 7 strategies for reading search engine results effectively, but in comparison to that at the age of 14 only 2 strategies for reading search engine results effectively can be expected from more than half of the science class.

Observing the results of teachers' evaluation of the competence for location the information by searching for the proper web site, we could say, this competence is not developed enough for implementing Internet as a learning source in the natural science education in the first half of compulsory school – at least not as a frontal didactical tool for all students

Table 3 shows that natural science teachers evaluate their student's competences for navigating on a website for information and learning as lower as their computer basics competences and similar as their competence for searching for a proper web site.

Table 3: Check list 3 Navigation On the web site

	Age 14	VOC.	gimn.
NAVIGATION on a Website			
Quickly determine if a site is potentially useful and worth more careful reading	3,00	3,61	3,41
Read more carefully at a site to determine if the required information is located there.	2,94	3,09	2,91
Predict information behind a link accurately to make efficient choices about where information is located.	2,31	2,86	2,86
Use structural knowledge of a web page to help locate information, including the use of directories.	2,69	2,90	4,50
Know how to open a second browser window to locate information, without losing the initial web page.	3,19	3,80	4,09
Know how to use an internal search engine to locate information at a site.	2,88	3,42	3,77
Monitor the reading of a web page and knows when it contains useful information and when it does not.	3,00	3,19	3,36

Natural science teachers expressed doubts about their gymnasium students' competence for navigating on the web site. They judge, only a half of gymnasium students can quickly determine, if a site is potentially useful and worth more careful reading, know how to open a second browser window to locate information, without losing the initial web page, know how to use an internal search engine to locate information at a site or monitor their reading process of a web page and know when it contains useful information and when it does not. The vocational education students have even more absent competences for navigation on the web page. Less than a half of them is able to predict information behind a link accurately to make efficient choices about the location of the information and to use an internal search engine to locate information at a site. The remaining five competences, needed for navigation on the web page, are in possession of approximately the half of students. None of them can be expected from all of vocational education students. At the age of 14, the edge of entering the upper secondary education, the situation is even more concerning. About the half of students can quickly determine, if the site is potentially useful, know, how to open the second browser and monitor their reading of the web page to decide if it contains useful information, but, less than a half of them can predict the information behind the link, recognize the structural knowledge about the web site to locate the information and know, how to use an internal search engine to locate information on the site. In general, the results, presented in table 3, are very concerning. They show a great lack of competence of navigation on the web page. And to highlight this result, the lowest scored competence in the group of navigational competences was the competence to predict information behind a link to make efficient choices where information is located ( $M = 2,86$  for gymnasium students'). This means that even on the doorstep of university according to the opinion of their teachers more than a half of students are not able of multi-layered inferential reasoning process, which is essential for searching and locating the information on Internet.

Table 4 shows how natural science teachers evaluate their student's competences for critically evaluating information in the process of learning.

Table 4: Check list 4 Evaluation of the information on the web site

	Age 14	VOC	gimn.
Critically Evaluate Information			
Identify, evaluate, and recognize that all websites have an agenda, perspective, or bias and identify and evaluate bias, given a website with a clear bias.	3,19	3,38	3,59
Identify and evaluate the author of a website whenever visiting an important new site.	2,31	2,71	2,86
Identify several markers that may affect reliability such as:			
▪ Is this a commercial site?	2,44	2,95	3,14
▪ Is the author an authoritative source (e.g., professor, scientist, librarian, etc.)?	2,44	3,00	3,00
▪ Does the website have links that are broken?	2,94	2,57	2,86
▪ Does the information make sense?	2,50	3,04	3,18
▪ Does the author include links to other reliable websites?	2,50	3,09	3,41
▪ Does the website contain numerous typos?	4,19	3,14	3,05
▪ Do the images or videos appear to be altered?	2,81	3,42	3,36
Understand that Wikipedia is a reasonable, but imperfect, portal of information	2,81	3,19	3,59

Comparing this judgement with their judgements of computer basic skills, the web site searching competence and the competence of navigation on the web site, we can see that a competence for evaluating the web searching result is significant lower as their computer basics competences and slightly lower as their competence for navigating on the chosen web site.

The competence for critical evaluation of information/knowledge, found on the web site, is, in teachers' opinion, quite low. Even among the population of gymnasium students just little over a half of students can identify, evaluate, and recognize that all websites have an agenda, perspective, or bias and identify and evaluate bias, given a website with a clear bias ( $M=3,59$ ). And the same amount of students know that Wikipedia is a not a perfect portal of information when they search for information or knowledge for their natural science assignment. The lowest developed competence is the competence to use the fact that the broken links are a sign for unreliable website ( $M=2,86$ ). This can be explained in the connection with the absence of competence for using knowledge about the web site structure, presented in the table 3. The vocational education students have even more deficits in the competence of evaluating the information on the chosen web site. About a half of them can identify, evaluate and recognize, that a web site has an agenda, perspective or bias, can decide, if the author is a reliable source, judge, whether the information makes sense, reject the site, if the web site contains many typos or if the images or videos appear altered, but less than a half of them know, if the site is commercial or not. And observing the results of compulsory school students at the age of 14, we can say, the competence for evaluating what is a reliable information and what not, is not sufficiently developed, to use Internet as the information source in natural science class, without teachers' didactical guidance.

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## DISCUSSION

The results, presented on tables 1–4, could be one of the answers to the central question of the presented research: are young people, members of the so called "digital natives", competent enough for the new pedagogical agenda of online learning? Are they all prepared for total switch to e-learning and to exclusively ICT supported teaching paradigm? The results of present research reveal that the generation of digital natives does not enter secondary school digital literate, and above all, they do not have the science literacies of online research and comprehension competence. This competence is a very structured competence and every structural element has, as the present research shows, different dynamics. If we can say, similarly as proven in the study Kordigel Aberšek et al. (2015), that the basic computer skills are sufficiently developed during the pre-university education, we cannot oversee, that competences searching for a proper web site, navigating on the web site and critically evaluating the results found on the web site develop much later, and that they do not develop in whole population simultaneously. The results, gained in the vocational educational population show the presence of well-developed basic computer skills but the concerning absence of competence for locating information by using the search engine, the competence of navigating on the chosen web site and the competence of evaluating, if the gained/found search results could be used in the learning process, if they can be reliable or not, if they can be trusted or not. As an

example, only a half of vocational educational students know and understand that Wikipedia is imperfect portal of information.

The results of the study must be observed in context of some other online literacy research, which explored the nature of Internet search strategies among students and found numerous obstacles to information seeking with open Internet text environments. As mentioned in the study *New Natural Science Literacies of Online Research and Comprehension: to Teach or not to Teach* (Kordigel Aberšek et al, 2015), readers on the Internet experience challenges associated with ineffective and inefficient processes (Bilal, 2000; Eagleton, 2003), cognitive overload and disorientation (DeStefano, & LeFevre, 2007), a tendency to drift from one search question to another (Lyons, Hoffman, Krajcik, & Soloway, 1997), and an inability to know how to use the information once it has been located (Wallace, Kupperman, Krajcik, & Soloway, 2000, Coiro, Dobler, 2007). Also A. Mangens' research of learning results, gained by reading linear and online text showed significant weaker results, when students tried to gain knowledge from screen, even more, if the studying time was time limited (Mangen, 2013). She explained such results in relation with issues with navigation within the document and the necessary scrolling, which is inevitable when reading longer documents. Scrolling hampers the process of comprehension, by imposing a special instability, which may negatively affect readers' mental representation of the text and, by implication, comprehension (Baccino, 2004). Similarly, DeStefano and LeFevre (2007) point out, hypertext confronts students with additional cognitive load and underlines readers with high prior knowledge are typically unaffected when the text structure was nonlinear and had many imbedded links. On the other hand, low knowledge students needed the guidance of information delivered by the information of the hierarchical structure of the text. DeStefano and LeFevre conclude their research with the warning: lower ability students need guidance in learning from hypertext, especially when hypertext is not optimally structured, when the choices are totally free (if they are not limited by nodes) – and the Internet texts as a rule do not contain restricted possibilities in the process of navigation between the links. The information gaps between information are for low pre-knowledge learners too big for building inferential bridges between them and to construct the text coherence and consequently the comprehension. To sum up, previous research and results of a present study; the competence for online searching and learning is a slow developing and structured competence. Some of its' structural elements develop even in non-simulative environments, when engines are used for socializing and playing, some of them, as searching for the proper website, navigating on the web site or/and evaluating on the web site, develop with a significant delay, especially in environments which do not support e-learning and which do not give opportunities to develop them.

## **CONCLUSION**

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Common opinion in digital natives' e-learning competence shows a very high opinion of their so called 'digital literacy'. It seems that there is no doubt in the fact the digital natives' generation does not need to memorize knowledge any more, since knowledge is at all times just a click away, and they are permanently connected and able to find it on the net. But, as closer research, including presented study, reveals, digital natives, at least half of them, have in the process of learning online remarkable difficulties, which will

seriously decrease their learning results, if the switch from conventional to ICT teaching paradigm will happen too soon and without differentiation according to the level of their online research and comprehension literacy competence. Digital natives, although they grow up in an online world and spend thousands of hours in online gaming, texting and socializing, have limited skills in computer basics and even more limited skills in searching for the information on the Internet, navigating on web sites and evaluating the information, they have found. Previous research, as well as the results of this study, suggests that instruction in online research and comprehension should be included in literacy curriculum (OECD, 2010) and that science research and comprehension competence should be included into the curricula of every natural science subject on all levels of the school system. To sum up with D. Boyd (2014): we shall not speak of digital natives. The digital native rhetoric is worse than inaccurate. It implies the taught that we do nothing about online learning incompetence of those, who would have needed teachers' help. By "not doing the work, necessary to help youth to develop brood digital competency, educators and the public end up reproducing digital inequality, because more privileged youth often have more opportunities to develop those skills outside the classroom" (Boyd, 2014: 150). And the gap between the privileged and non-privileged will be even bigger as it used to be, when students and their teachers were using only books.

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# Petri Nets Tool Creation for Process Visualisation and Formalization

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## Abstract

*The paper describes the creation of modelling and simulative tool of Petri nets by means of which it is possible to simulate processes and it enables a vast tool support in the fields of model check, graphically oriented simulation and software verification. The advantage of process modelling with Petri nets is their formal description, which refills the graphical display. There are numbers of editors and tools for Petri nets modelling and simulation on the market. By the use of the created simulation tool of Petri nets it will be possible to model and simulate and consequently to form the processes running on the systems. The important aims of the designed tool is to create, model and visualize processes in the operating systems of PC, to create appropriate models which optimize progress in educational processes and to implement IF-THEN rules into modelling processes. The first part is concerned with the definition of the basic terminology from the fields of modelling, the principles of modelling and simulation, and the basic features of Petri nets. The implementation of forming into Petri nets tools has given a strong tool to model real processes. By means of the created tool it will be possible to model and simulate the processes in operating systems, educational processes in LMS and possible to model IF-THEN rules, or fuzzy Petri nets.*

## Keywords

*Petri nets. Tool. Modeling. Simulation. Formalization. IF-THEN rules.*

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## INTRODUCTION

Introduction and report of any process requires solution, check, observation, optimization description and par excellene simple expression description. The investigators consider Petri nets as the ideal tool to record all the changes needed. Petri nets support complex system designs with parallel processes and hierarchical structure. One of the advantages of process modelling by the nets is their formal description refilling the graphical display by which a precise and an exact specification of a process is possible contributing to eliminate ambiguity, uncertainty and contradiction. Petri nets also have solidly defined mathematical bases. The simplicity of the basic user interface enables an extensive tool support in the fields of model check, graphically oriented simulation and software verification.



The concept of model is been regarded as a created system which is a particular (many times an important) simplification of the modelled system original. Between the original and its model, there is a homomorphic relation of displaying while it is needed to differentiate the abstract ones from the simulation ones. By the abstract models (theoretical) it is possible to take logical reasoning and by the simulation models (implemented) to practice simulation experiments. Some models implemented through computers might belong to both categories at the same time because they provide theory (enabling by logical derivation to prove the features of the model) and it is also possible to practice simulation experiments with the model (Peringer, 2008) (Hubalovsky, 2012) (Skorpil and Stastny, 2009), (Minarik and Stastny, 2008).

The simulation might be defined as an imitation of a real object, state or process. In general, the act of simulation requires a representation of particular key features, behaviour of a chosen physical or abstract system. Simulation as a concept means an artificial replication of the sufficient components simulating the real world to gain specific goals. The concept includes various fields of as modelling biological or human physiological systems, technological reproduction of tools and environments, or complete virtual worlds, environments created by computers in which it is possible to move (Fanning and Gaba, 2009) (Molnar, 2014).

To form a proof or a concept includes securing the fact that every step or image is explicitly defined and explained in a way, so that no detail would be overlooked. In common mathematics the proofs are not formed because a big amount of effort would be needed to achieve a task regarded to be meaningless. One of the protests against the use of formal proofs is that they slow down the understanding of the basic concept, which they prove. If understanding was regarded as fundamentally linked to proof, this barrier would exclude formal proof as such Thompson (Thompson, 2015).

Nowadays, Petri nets as a tool of modelig systems are one of the often used methods for modelling and simulation of process systems in various fields (Balogh et al., 2013). They are useful when modelling because they combine discrete events and joint events in an easily comprehensible way. On one hand, they are appropriate for modelling the discrete parts of systems and for providing of discrete abstraction of joint behaviour. On the other hand, generalized stochastic Petri nets can dynamically describe the system and have a good detail simulation skill (Zhang, 2008).

The formalism of Petri nets with all expansions is so strong, that there are included almost all other formalisms. There is only one formalism needed without taking into account the chosen modelling approach (qualitative vs quantitative, discrete vs joint, deterministic vs stochastic) which is appropriate for the observed system. Moreover, formalization of Petri nets is easily comprehensible for scientists from various fields who cooperate on the modelling process. It is an ideal way for intuitive representation and communication of the observed system. Besides, Petri nets enable hierarchical model structuring and enable various detailed views on the observed model (Pros et al., 2012).

The aim of the paper is to describe the creation of the modelling and simulation Petri nets tool by the use of which it is possible to model and consequently simulate the processes. It enables a vast tool support in the fields of model check, graphically oriented simulation and software verification.

## THE DEFINITION OF THE PETRI NETS CONCEPT

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Petri nets (PN) are an appropriate graphical and mathematical tool for modelling, analysis and verification of discrete system features.

PN represents an oriented bipartite graph containing two types of knots: places and transitions, which are mutually linked by arcs. The attribute oriented means that the arcs in the graph are oriented. The attribute bipartite represents a state where the set of graph knots consists of two mutually disjoint subsets (set of places and set of transitions). In graphical representation of PN, the places are displayed as loops, and transitions as rectangles. Arcs link the place with the transition, or the transition with the place.

The marking or the state assigns a non-negative integer to each place. If the marking assigns a non-negative integer  $k$  to a place  $p$ , it means that it is marked by  $k$  tokens. In graphical representation, PN is placed in into a loop symbolizing the given place to the points.

Each element of PN are shown in Figure 1 while it is valid that:

- the place might contain a non-negative integer number of tokens,
- in the moments of transition activation, tokens from input places are removed and put into the output places of the transition,
- the oriented arcs link places and transitions,
- the initial marking (placing the tokens in places before the first vault) describes the initial state of system,
- the development of the system is presented by the movement of tokens in the net on the bases of activation of the transition,
- each new marking represents a new state.

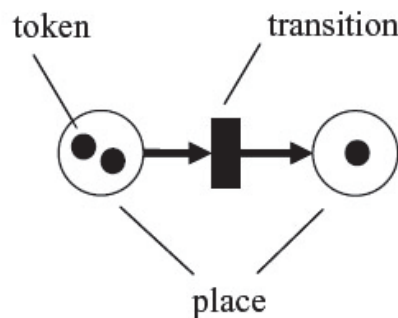


Figure 1: Components of the generalized Petri nets

Generalized PN (GPN) represents an arranged pentad according to (Balogh et al., 2011):

$PN = (P, T, \text{preset}, \text{postset}, M_0)$ ,

where  $P = \{p_1, p_2, \dots, p_m\}$  is the final set of places,

$T = \{t_1, t_2, \dots, t_n\}$  is the final set of transitions,

$\text{pre}: P \times T \rightarrow \mathbb{N}$  is the function of input arcs,

$\text{post}: T \times P \rightarrow \mathbb{N}$  is the function of output arcs,

$M_0$  – is the initial marking,

While it is valid that  $P \cap T = \emptyset$  a  $P \cup T \neq \emptyset$ .

The exceptionality of GPN is that the arcs are marked by the values of predicates *preset* and *postset* representing the evaluation scale of arcs and usually is recorded in charts. All other arcs which scale is not specified have the value of evaluation equal to 1. The arc  $k$  is possible to specify as  $k$  to parallel arcs. Each GPN is possible to transform to a standard PN (Balogh and Turcani, 2011, Balogh et al., 2012)

When simulating the dynamic behaviour of the system, the state or marking in PN changes according to transition rules which is sometimes defined as firing rule (Sabot, 1992):

1. Transition  $t$  is enabled if each input place  $p$  of  $t$  transition is marked at least by a preset  $(p, t)$  number of tokens.
2. The enabled transition might but does not have to activate depending on the fact whether the relevant event has occurred or not.
3. Firing of the enabled  $t$  transition eliminates the preset  $(p, t)$  number of tokens from each input place  $p$  of transition  $t$  and adds the postset  $(p, t)$  number of tokens into each output place  $p$  of transition  $t$ .

From these rules for transition activation it is possible to deduce some characteristic constructions which appear when modelling system with Petri nets (Murata, 1989):

Marking, enabled transition

Marking determines the number of tokens in each places. Informally it is possible to understand the marking as the distribution of tokens in the net.

Let  $N = (P, T, F)$  Petri net. Marking is function  $M: P \rightarrow \mathbb{N}_0$ .

Transition  $t \in T$  is enabled in  $M$ , as long as

$$p \bullet : M(p) \geq F(p, t)$$

If there was an equality in relation, then PN would be as strong Turing's machines and many features would be undecidable. The equality in this kind of modelling use would bring problems.

Transition system of PN

Let  $N = (P, T, F)$  be Petri net and  $A$  is a set of signs (alphabet). Let be a function  $l: T \rightarrow A$  assigning through transition not necessarily mutually different signs. Transitional system with signs for Petri net  $N$  with marking  $1$  is defined as

$$TN = (S, A, \rightarrow)$$

where  $S$  is a set of all markings,  $\rightarrow S \times A \times S$  a  $M \rightarrow a M'$  just when there is a transition  $t \in T$  enabled  $M$  in a way that  $l(t) = a$  and

$$p \bullet : M'(p) = M(p) - F(p, t) + F(t, p)$$

## Basic concepts concerning GPN

*Simultaneity* (transition through multiple output arcs) – construction where there are multiple simultaneously completed and independent sequences created from one process sequence.

*Synchronization* (transition with multiple input arcs) – constructions where there are some sequences mutually waiting one for the other and consequently continue with one sequence.

*Connection* (place with multiple input arcs) – construction which connects some possible ways of system development into one way.

*Alternative* (place with multiple output arcs) – construction which enables the token to move various ways.

The most spread modifications of PN are:

- Joint PN – implementation of real numbers to mark places.
- Hybrid PN – combination of joint and discrete places and transitions.
- Stochastic PN – to each transition there is assigned an arbitrary variable.
- Timed PN – time delay of places and transitions.
- Colored PN, High-Level PN

## PETRI NETS MODELLING AND SIMULATION TOOL DESIGN

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The paper deals with PN modelling and simulation tool design – TransPlaceSim (Figure 2.). The program is written in C++ language and created in IDE MS Visual Studio 2013 which means that the user must have MS VS Redistributable package (x86) installed on his PC in order to launch the program. The program uses DirectX 11 API for graphical user interface. The program serves to create models and simulations of PN. The main elements of PN are places, transitions and arcs. To insert the elements into the model it is enough to push the keys P for places, T for transitions and click with the mouse on the place where the element is needed to be put. If the elements are needed to be connected the key A is needed to be pushed and click on the element from which the arrow is needed to be be dragged. Consequently, click on the element to which the arrow would be dragged.

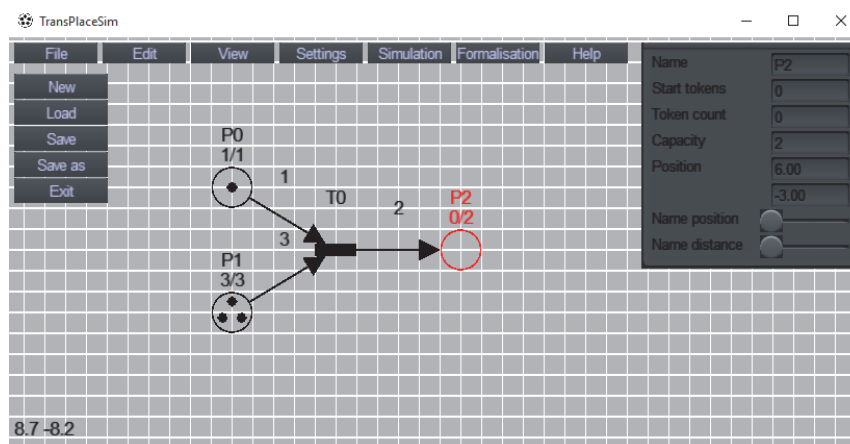


Figure 2: Program environment of PN – TransPlaceSim

## The features of elements

After marking the particular element (place, transition or oriented arc), in the right top corner a window would appear with the features of the element.

For places it is a name, the initial number of tokens, the actual number of tokens, the capacity of the place, its position (x, y) and scroll bars by which the position of place name and the distance of place name would be set.

For transitions it would be its name, time type, position (x, y) and scroll bars by which the position of transition name and the distance of transition name would be set. Timing types of transitions determine whether the transition activates when it fulfills the activation conditions. Immediate transition activates at once. The deterministic activates when a stagnation has occurred in the system meaning that no other transitions can be activated in the same step. The stochastic transition activates if its arbitrary time has been dropped to zero in the particular step.

For the oriented arc it is its scale, which determines how many tokens the arc assigns to places and how many it takes. Then it is information about which place and transition the arc connects and scroll bars by which position and distance of oriented arc data are set.

When marking multiple elements at the same time, their parameters cannot be changed.

## Simulation

When clicking on the bookmark *Simulation* a menu of simulation appears. By pushing the button *Reset simulation* the actual number of tokens of each place would be set as the initial number of tokens. Pushing the button *Step forward* a step of simulation would be completed. The simulation starts by pushing the *Play* button. The launched simulation is marked with a red margin on the window. The simulation can be stopped by the button *Stop*. The scroll bar serves to set the speed of simulation animation.

In simulation, transitions activate according to activation conditions resulting from PN definition and according to set time type.

## Formalisation

There are some possible formalisations. After clicking on *Formalisation* a menu of possible formalisations appear.

The first possibility is *Display steps as vectors*. It displays the state of the model as a vector while the values of vector are numbers of tokens in places. In this formalisation it is possible to learn into what kind of states the model can get from the original state set at the beginning of the formalisation. At each state vector there is a pair of numbers determining the next states. The first number represents the line of the next state and the other number determines the place of the state in the line (Figure 3.).

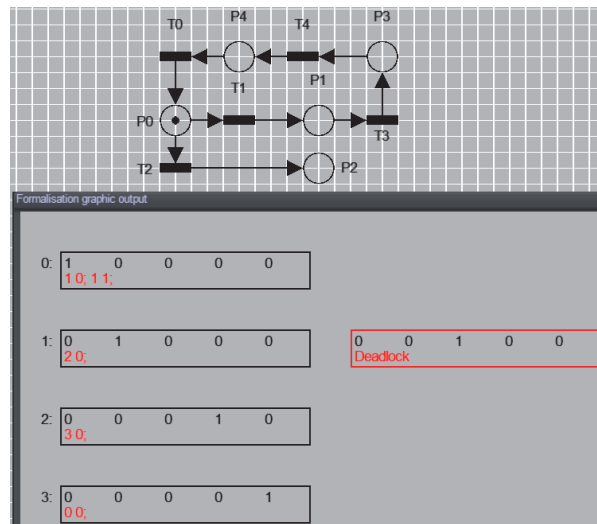


Figure 3: Display steps as vectors Formalisation

Another formalisation is *Vectors with transitions*. It functions similarly as *Display steps as vectors* but apart from token vectors it records the transitions activated when adding tokens and also from which places the tokens were taken. The difference is that the model can get into the same states by activating various transitions (Figure 4.).

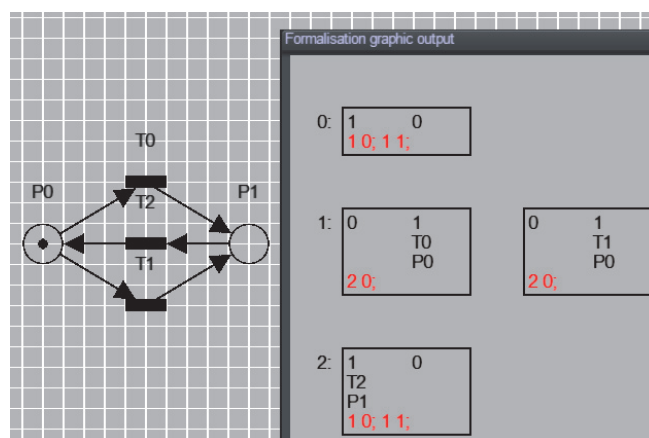


Figure 4: Formalisation Vectors with transitions

*Incidence matrix* is another one in the *Formalisation* bookmark. It records the incidence matrix for the particular model in three ways. The first one writes the names of transitions as columns, the place names as lines, and values of oriented arcs for a particular place in the matrix. Then there is a matrix form used in MatLab program. The last one is a form of a two-dimensional array used in language C++.

*Display IF THEN stepwise* is the next formalisation which records the steps from *Display steps as vectors* as IF-THEN rules with operators AND and OR.

IF P0 THEN P1 OR P2

IF P1 THEN P3 OR P4

IF P2 THEN Deadlock

IF P3 THEN Deadlock

IF P4 THEN Deadlock

an example of recording Figure 5.

*Display likelihood table* is the last formalisation where it is needed to determine the number of steps. It records the states of the model as vectors and to each state in the step it records with what likelihood would this state happen in this step (Figure 5).

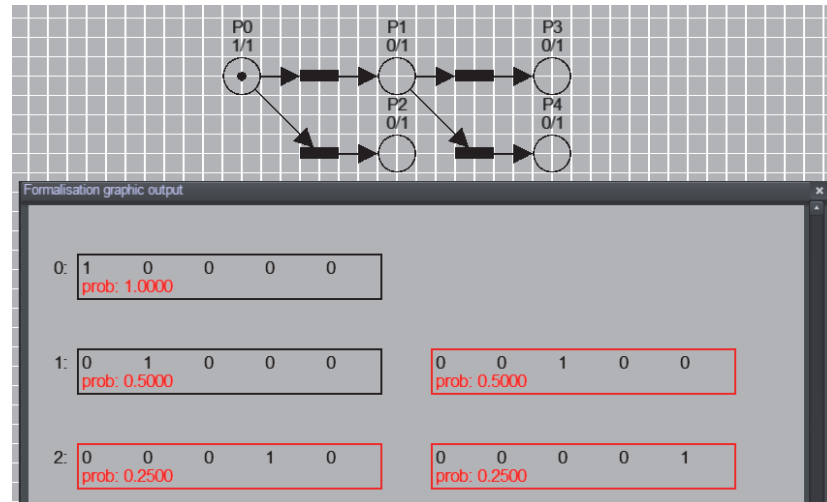


Figure 5: Display likelihood table Formalisation

When calculating the likelihood it is needed to proceed as follows. To the initial state of PN the likelihood 1 is assigned. In the cycle another states are observed that might happen for each state of the particular step while:

the likelihood of state = (likelihood of initial state/ number of possible states) \* number of same states which have been created by activating other transitions

By calculating the likelihood it is easy to find out the likelihood of appearance of particular states which the system might acquire.

## DISCUSSION

System modelling is an activity which enables to think about the real world according to gained knowledge and thus consciously influence it. The concept of system usually represents a reality abstraction while those facts are taken into account which are relevant for research. The modelled system has its structure so it consists of parts (elements or units of the system) among which there are certain bindings or relations. In a dynamic system the bindings might change as well as the set of system elements (Křivý and Kindler, 2001) (Rauchová et al., 2013). To record the running processes in systems various advantageous simulation tools are used by which the particular systems are being modelled and described. On the market there are many tools for modelling and simulation but not all of them fulfill the particular requirements of the given situation.

The paper describes the PN modelling and simulation tool creation by which it is possible to model, simulate and consequently form each process in particular systems. Creating system models is one of a widespread activity from the beginning of human existence. It can be said that our imagination is in fact a model of reality, of outside world.

which can be examined. When modelling information about the system is taken into account which are accessible. The created model represents formalised knowledge about the modelled system from the point of view it is going to be examined and usually it represents that part of system description which is important for that given purpose. Because the model is based on incomplete knowledge, it is possible to model only that part which we are able to understand and describe. Simulation modelling represents a transformation process of knowledge from a machine unacceptable representation to a computer acceptable representation.

Understanding the principles of modelling and simulation requires at least informal definition of some basic concepts. Computer model is a system imitation by another system, by a computer program. System model must imitate all the important system features for all purposes because it represents formalized knowledge about the modelled system from the point of view of the examined object.

## CONCLUSION

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The aim of the paper was to describe the PN modelling and simulation tool creation by which it would be possible to model, simulate and form. The use of the tool is broad spectrum, i.e. from the educational process description to modelling of manufacturing process in the industry. The priority of the created PN tool is to familiarize students with the possibility of modelling simulation and formalization of processes and to explain them the problematics. Using the tool in the learning process would help them to understand many phenomena and facts which run in the systems such as in subjects Operating Systems, Computer Networks, Programming, etc. On the market there are many PN tools but the majority has no possibility of formalization. In the future there are plans to place in Operating Systems in which there are modelling processes by PN to this day and to find out the efficiency, variability and reliability of the created PN tool.

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# Non-traditional Education Using Smart Devices

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## Abstract

*The report is oriented on creation of mLearning educational content. Nowadays, form and method comparisons of traditional education with e-learning support and their combination result from always new technology, mostly mobile ones. Preparation and adaptation of digital educational content from e-learning to mLearning by keeping the education quality is another topic to be discussed. The fast development and penetration of mobile technology requires new skill and knowledge acquisition in this field. It obliges the user to gain higher level of digital competence. The academic field is not an exception. It is the aim of professional programmers to create native applications for mLearning. Their production just for one platform is financially demanding and time consuming. That is the reason why there are freely available tools and applications by the use of which it is possible to create educational apps for all platforms. There is no need of programming knowledge to create them. The adaptation of mLearning contents using the eLearning contents has its particularities. The principle of a good mLearning is based on displaying the educational units in mobile devices. It is diametrically opposed to displaying contents in eLearning. Redesign is the only way how to provide the user with good access to all educational contents. Educational material content creation relates to cloud service use which has a great impact on application availability and sharing. A choice of an appropriate environment depends on the user. In the end of the report, there are recommendations not only for mLearning content creation but also for cloud application.*

## Keywords

*ELearning. MLearning. Native Application. Digital Learning Content. Competencies. Redesign.*

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## INTRODUCTION

Development and use of new technology, mostly mobile ones, has influenced our everyday life, our work, and our education. Their primary function – communication – has lost its priority among the services they provide today. Acceptance of the new technology in college area is more than a use of technical innovations. Its implementation requires clear university policy, availability, use of trendy technology, pedagogic support, and digital competence of teachers. The competences result from skill and knowledge level assessment of a 21<sup>st</sup> century teacher. Digital competence is a bridge between traditional form of education and progressive education of today's digital era.

## FORMS OF EDUCATION

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The traditional education is characteristic for its frontal approach where there is only one teacher. The typical teaching methods like verbal or graphic demonstrational is combined with energizing methods – discussions, problem solving, didactic games, brainstorming, projects, and other methods. By using the information and communication technology in teaching, it is possible to eliminate the shortcomings of the traditional teaching and thus create an engaging, addressed and interactive teaching. The main asset of eLearning in traditional teaching is the alternative of teacher relief from providing information which the learners may acquire on their own. They can pay more attention to problematic fields, discussion or practical activity. To understand some processes, it is easier to use eLearning animation than long-lasting lectures of teachers. For purposes of increasing the knowledge acceptance, personalizing the learning process has its importance. Here, according to identification of personal characteristics, teaching materials would be created which would fit the learners the most (Kostolányová, 2014).

In Slovak Republic, colleges and universities have participated the most on the combined form of education (the traditional with the support of eLearning). ELearning has been more closely involved from 2000 here. Progressively, new didactic approaches and principles were created; content and performance standards have changed. Abroad, mostly in business and production area, eLearning has progressed around 2000.

ELearning can be characterized by three key words: structured, formal and timed. By creating the virtual educational managerial environment, the so-called LMS, managing and controlling the teaching by the tutor (teacher) has been enabled, as well as an individual set of environment for each student. LMS has been mostly implemented at universities. LMS Moodle has been the most widespread environment. It contains tools and activities which can be used to create an arbitrary type of teaching module (course). The integrated modules consist of various interlinked lessons (batch of curriculum). Each lesson has its own linear structure: motivations and objectives, lecture constructed of page series containing technical text and pictures, animations or short videos, summary of the lesson, revision test with an immediate feedback. This kind of teaching programme provides the students with the same lecture and the only possibility of repeated passage. Teaching modules with branched programme represent a higher level. They react to the quality of the student's response and lead him through alternative branches. The creation of integrated teaching modules for university students stayed on the optional initiative and competences of teachers who were willing to innovate and make the educational process more effective.

### Digital learning content

In order to improve the quality of education, it is essential to combine the learning activities with information and communication technologies thoughtfully. By inappropriate combination of various forms and methods, education may affect confusingly.

To create a good digital learning content (DLC) into eLearning environment, the process of creating it is not demanding in the way of its production but it is time consuming because each creator has to sacrifice his or her own free time. In the process of preparation, as mentioned above, it is required from the creator to construct the structure of the whole module. Besides, it is needed to prepare the study material where the

creator needs skills to filtrate and combine the graphic elements, assignments, tests, questionnaires, sequences of videos or podcasting, and other activities the system provides. The last but not least, he or she has to have digital competences and skills. As Beisetzner (2011) says, it is required for the creator to have skills and at the same time recognize the real state of eLearning, to assess from the points of view of:

- theoretical bases of the problems,
- appropriateness or inappropriateness, when dealing with the course
- opinion of students using eLearning.

On the level of primary and secondary schools, eLearning has not taken charge for a longer time. Problems were caused because of poor ICT facilities in schools and with weak or also with no connection to the Internet. Schools which joined to utilize eLearning used DLC provided by the Ministry of Education, Science, Research and Sport of the Slovak Republic or by methodical centres. At the beginning, the DLC was transformed from foreign sources and thus they did not correspond to the curriculum of the Slovak Republic. Later, various companies tried to create DLCs, but many times they did not own specialized experts in technical topics. Teams of specialists have been put into charge that was confirmed by the Ministry. As sources state, there are more than 30 000 materials provided via an educational portal "*The Planet of Knowledge for Schools, Teachers, Pupils and Public*" ([planetavedomosti.iedu.sk](http://planetavedomosti.iedu.sk), 2015). Study material is created by multimedia content in a form of videos, animations, simulations, presentations, illustrations, 3D models, pictures, photos, interactive exercises and lessons. An educational portal for modern teachers *Naucteviac.sk* contains more than 50 000 interactive teaching activities. Teachers of primary and secondary schools are provided by various online tools for simple material search, study material preparations for lessons, creating assignments and home works for students and their check. Materials are continually being refilled and updated. Each DLC before categorization into the educational portal undergoes a quality check whether it corresponds the curriculum. (iEDU, 2016; Šimánek, 2015).

## Mobile Technology

The penetration of mobile technology into everyday life, mostly of smartphones and tablets, has increased the importance of information and communication technology in communication between people, institutions and offices. It has influenced electronic services, entertainment area and relaxation. Their more widespread use has got control over mainly the generation Z – digital natives. As Urban (2015) states, there were only few smartphones ten years ago comparing to today and the majority of people had the ordinary mobile phones, appointed for communication. First intelligent phones – smartphones were quite expensive, complex and with a short battery life. It was only in 2013 when the sale of smartphones has overcome the sale of ordinary ones. The screen had to be controlled by hardware buttons. Today smartphones have touchscreen thus enabling simple manipulation.

According to Statistical Office of Slovak Republic, in Slovakia there were more than 5.9 million customers of mobile network at the end of 2011. If we compare the number of all inhabitants, it means that each inhabitant of Slovakia owned at least one mobile phone. The web page [itnews.sk](http://itnews.sk) brought the following statistics: the penetration of mobile services in the third quarter of 2015 has reached 124.49 %. Companies such as Orange Slovensko,

Slovak Telekom and O2 Slovakia have registered together 6.7 million of active SIM cards. Without a phone/smartphone, 36 % of persons would not be able to hold on and around one fifth of the Slovak population has declared an addiction to PC, notebook, tablet or Internet. By this addiction, young people between the age of 14 – 34 are the most under threat. Those are students, educated, enterprisers, and white collars.

### **Modern teacher and modern technologies**

The relationship between modern technology (mobile) and a current teacher is many times understood as digital literacy acquisition which is in most cases acquired informally. The formal way is used by people who are required to have deeper knowledge within their work duty (SITA, 2015). Often it is possible to meet a teacher who claims to have digital competence because he can work with the computer and the Office. He might have learnt some small application programme and created some partial base. Although, digital competence has a broader concept which official documents such as OECD, UNESCO or the European Union also declare. Digital competence does not contain only computer literacy, but has also other components. For instance, those are the overall skill of the teacher to understand digital didactics, organize DLC, develop DLC, create lessons with digital aids, and to effectively use DLC in his educational practice, as mentioned by Verlík (2016), a consultant for digital education and multimedia.

Acquisition and deepening digital competences can be defined as multiple periods. They start at the level of literate use, through the level of competent understanding, to the level of creative use. From the periods, the creative use is the demanding and complex one. It does not work without inner motivation, willing to learn with the learners, participating, creating joint projects with pupils. With them, pupils can acquire digital competence and are educated to active, motivational and creative approach to life. Digital creativity is able to enrich the traditional educational tools and methods by playfulness, modernity, shared responsibility and a permanent willing to learn.

By penetrating the mobile technology into primary schools, other formal and informal teacher education has been supported (Euractiv.sk, 2016). Many teachers who have been educated started to use mobile technology, mostly interactive boards and tablets in their teaching. One of the first projects which was oriented on mobile technology application (specifically tablets) into education was the project “School to Touch” (Skolanadoty.sk, 2016). A non-profit organization EDULAP in cooperation with the company Samsung Electronics Czech and Slovak, s.r.o. have started it in 2013 as a pilot project for primary and secondary schools. The aim of the project was to supply schools not only with tablets and other touchscreen devices but mainly to create a long-term working environment for their use in education. In this project 15 educational institutions are involved; from that 9 primary schools and 3 high schools. Through a special web portal, teachers and students share used educational applications or created methodical materials. The enthusiasm and the initial experience of teachers in the project indicate that touchscreen technology makes pupils active, brings motivational potential and create appropriate conditions for learning.

The project has been expanded by 3 universities because of linking future teacher education for secondary and primary schools. “School to Touch – University” is part of the project oriented on activities implemented in cooperation with universities educating

future teachers. The result of the project would be that the education of future teachers would take place in conditions which would be the same in their future employment.

### Adaptation of the m-learning content by adjusting the e-learning content

Some authors consider mobile learning only as an extension of e-learning or as a subgroup of e-learning. While it is possible to browse eLearning DLC on a mobile device, it does not specifically mean it is m-Learning. Balogh and Koprda (2014) state that if we want to set the right e-learning system for users, it is essential to create a detailed model that covers all the peculiarities of the given system.

It is not possible to squeeze the DLC e-Learning modules to your mobile device in a way they were developed. Adapting m-Learning into education is conditioned by creating or sharing educational contents, which are not different from e-Learning. The viewing area differs, which gives uniqueness to m-Learning. DLC, which were designed for personal computers or laptops, are not the most suitable for small display screen of mobile devices. Moreover the access to educational content it is unique and very different.

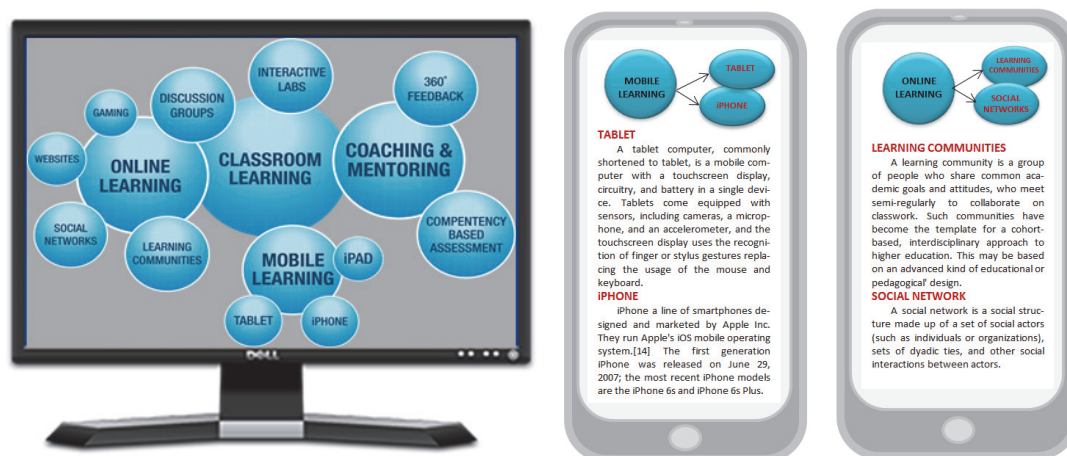


Figure 1: View of the DLC on a personal computer and on a mobile device

The quality of e-Learning can only occur in given certain special advantages and limitations of mobile devices. Obviously, the advantage of mobile learning is the mobility by which it differs the utmost from e-learning. E-learning is tied to the educational space, fixed internet connection and a desktop computer with accessories. Students access this form of education by reserving exact time and place. He or she shares LMS system with other users. He communicates online or offline. He approaches the m-Learning individually, at any time and any place. He communicates mostly online. Learning styles are another important attribute. Students should be aware of their learning styles, they should know what their strengths and weaknesses are, and should be provided with a variety of instructional methods and approaches to choose the most suitable ones (Šimonová et al, 2010).

Mobile learning differs from e-Learning in the following features: personalization, wireless connection, unlimited space and time, interactivity, special edition of DLC, style of education and the entertainment value.

There are several ways to adapt an existing e-learning content to m-Learning. Small adjustments will help only partially, the most appropriate way is to rework the e-Learning module completely. Redesigning is always the best choice. We assume the major redesign steps:

1. Modify the existing DLC by breaking it down into small units.
2. Optimize the size and the amount of text – good readability.
3. Optimize the size and the amount of graphics - good resolution.
4. Provide easy and fast access to the DLC.
5. Convert animations and video clips to a suitable format.
6. Develop podcasting and combine it with graphics.
7. Create control tests.
8. Create, for example, a study game with educational content.
9. Create other additional content.

Mobile learning provided by native mobile applications requires the users to download these applications from server to their mobile phones. In this case, application developers must also follow the continuous technological progress and the development of new display units. Native applications provide unique and rich user experiences. This is a very time-consuming and costly development (Enyotalearning.com, 2016).

Creating custom applications is easier, because the development of original, authoring tools do not require knowledge of programming. They offer compatibility with a wide range of browsers. The cost of development and management is very low compared to the native application because the application can work in various operating systems without problems. It is very easy to organize such applications on any compatible mobile website or in LMS system. Using the cloud storage, students gain quick and easy access to the DVO. Shared content can be used immediately without having to download or install anything from the Internet (Clothier, 2016).

### Design of DLC in mobile devices

As mentioned above, the text and image content on a mobile device must meet certain criteria. Texts must be simple, straightforward and brief reflecting the essence of the problem. They must enable quick reading and easy memorability to the users. It is probable that users will not sit at a desk when they want to access mobile content. They can move anywhere, at any time while using this waiting or traveling time efficiently.

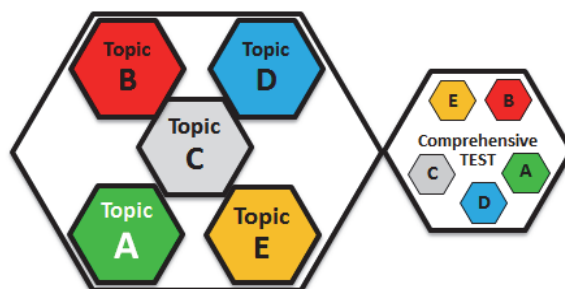


Figure 2: Division of training modules for e-Learning in LMS

Specialized texts, which are composed in e-Learning into larger units, lessons, or e-books, have to be distributed to smaller content-relevant parts (Figure 2). Do not use hyperlinks to avoid the referencing to other content. Loading additional content will cause loss of time. The effectiveness of a successful mobile application is not in a large amount of text and reading from a small screen. Text format must be selected very carefully.

It is appropriate to simplify the graphics totally or re-divide into parts and provide it on the next image also with podcasting. Any graphics that requires further careful studies will certainly not be appropriate to access through mobile devices. In e-Learning a detailed diagram can be on one screen. In the mobile device, each element of the scheme must be shown through the sections that have specific graphics, text content or animation. Easier part can be explained fairly quickly. Full graphic composition should then be built from these parts and each discussed separately (Figure 3).

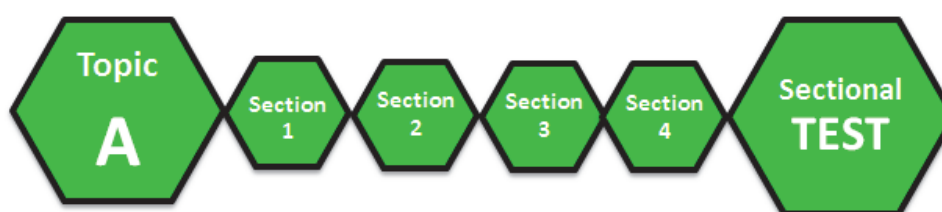


Figure 3: Division of training modules for m-Learning

### Tools to redesign e-learning modules for m-learning application

The most necessary tools for teachers to redesign modules are those available on the Internet for free. A very useful application to edit text and static graphics is *Tuul*. Every teacher who teaches via digital materials will appreciate it. The application not only allows creating custom texts and graphics, but also connection of materials with all the accessible online resources, e.g. DLC from the above mentioned projects.

To play animations and videos on your mobile device, which are most commonly found in e-learning in a Flash format, conversion is necessary, because they cannot be viewed on some mobile devices, for example, on iPhones. But there are tools that can convert source Flash files into HTML5 or to load Flash content as MP4. Another alternative may be creating multiple sequences of images with text and podcasting. Podcasting in e-learning can be put directly into MS PowerPoint presentations, or must be created in MP3, MP4, WAV, WMA format etc. It is appropriate to use programs for creating podcasting such as Audacity, Winamp, iTunes, MP3 KnifeDiktafón, Audio Record Wizard and many more.

A variety of applications allows testing the knowledge of students. A very widespread application among teachers is *Socrative*. It is an intelligent system that allows teachers to involve the pupils through their classroom in a series of educational activities - tests, exercises and games. *Socrative* helps to make education more engaging and interactive. It works on a typical web interface and can run on any device with internet connection. Tools for creating educational activities are simple. The teacher can immediately visualize the results.

Application Kahoot! is one of the other options of playful learning. Same as the previous application, it also works on both fixed and mobile devices. The application provides a wide range of education through educational games and supports better



understanding of the DLC through playing. It is needed to add questions and answers. For better understanding of the questions, it is possible to use videos, pictures or diagrams. It is also possible to use e.g. setting timer, giving points for correct answers and so on.

*Clarisketch* is an application that helps teachers to explain anything very easily. Just by using drawing schemes, images, screens, maps, diagrams or photos and commenting on them by votes. Another useful mobile application suitable for high school students – graduates is, for example, *Zmaturuj.sk* application. It contains 22 themes, 620 topics, more than 160.000 words. It has a simple design and necessary information in a minimum size.

Orientation of the display area is an important attribute of graphics, which is intended for e-learning. These are mostly oriented to landscape, thanks to standard desktop setting. But the mobile device user will probably hold the device vertically oriented. So the creator must have this important fact in his mind. Structures must avoid DLC types that require you to rotate the display. Using both hands is evaluated as a design error and reduces the value of application usage (elearninginfographics.com, 2016).

As well as in e-learning, it requires a thorough analysis of provided materials to create mobile content, as well as proposals of appropriate and attractive contents and mainly support of the management of educational institutions for implementation of the DLC. The evaluation is the last stage of the implementation process. It comes after the pilot/first verification of the project. It is usually done by experiences of the creators and mostly by reviews of the mobile learning students.

## Cloud computing future of education

Cloud computing is an information technology, data storage, which allows using software applications located in the Internet environment. These applications are the modern alternative to applications that are installed on the local computers. To use Cloud computing applications in administrative sphere, just Internet connection and a web browser is needed companies such as Google, IBM and Microsoft offer cloud for free, without the cost of providing the education system. If used properly, it can provide quality education.

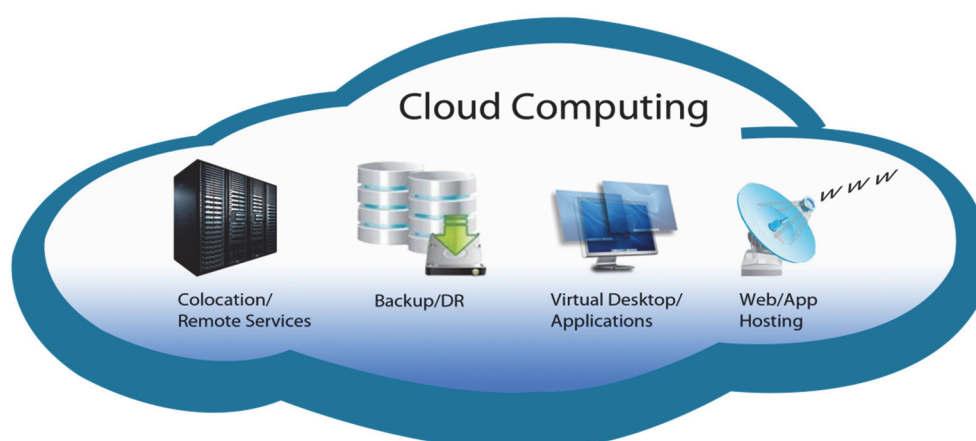


Figure 4: Cloud Computing

Cloud computing in e-Learning allows teachers and students access to educational content, without any installation on their own devices. The application will run directly through any mobile browser. Educational content is delivered immediately because there

are no following stages in the starting. Its update is seamless and the updated parts are immediately available. Educational institutions using this technology do not have to worry about upgrades of these applications. Supporting education, delivered via cloud computing, benefits from lower costs in the long run. E-learning in this form provides the opportunity to keep up with the latest technology. The trend shows that the future will undoubtedly belong to cloud computing and mobile devices.

## CONCLUSION

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Increasing globalization, competition and general saving, constantly forces organizations to rationalize their own work processes, otherwise it may lead to destruction or loss of position on the markets. Many studies abroad show that the benefits of new cloud computing approaches in IT are so important that those who cannot use them on time, will have the same or even increasing costs, while potential competitors could reduce their costs.

In conclusion, a thought to consider. Education cannot resist the current trends in technology and should introduce effective tools applying adequate techniques and methods (Burgerová, Cimermanová, 2014). The school has changed, despite the opinion of specialists in pedagogy, psychology and departments. We are located in the epicenter of technology development together with development of sources of knowledge in form of data space. Despite the fact that most of our classrooms were built with the assumption that it is difficult to get information, today all human knowledge enters this space. Lecture rooms were originally built to ensure the transfer of knowledge from the authority of the teacher down into the auditorium. Suddenly, they are filled with a cloud of ubiquitous information. Knowledge is not searched, but rather created. Our students clearly indicate us that the walls of our classrooms have ceased to keep the function of limitation that separates the inside from the outside.

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# The Quiz Questions with Automatically Generated Images

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## **Abstract**

*The contribution introduces a new feature of an automatic generator of parameterized questions. The image as a new data type of the input variable parameters is presented and a possibility of inserting images into the question and the answer text is described. The content of a variable image is randomly generated with respect to the values of other generated parameters in the question text or answer text. In the article the whole process of generation of images and questions is explained including the consequent transformation into demanded output formats. Different approaches of image processing are explained with respect to different output formats and with respect to image placing in the different part of generated tasks. The generated image can be placed into the task text as well as into the text of particular options in the case of multiple-choice question. The results of the described process are presented on the examples of different output formats.*

## **Keywords**

*Automatic generation of parameterized images. Automatic generator of questions. XML. XSLT.*

## **INTRODUCTION**

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Automatic generation of parameterized task can generate a unique problem for each student. Student can practise one task with different input parameters. It helps to understand problem from different points of view. The images used in the task help to better comprehension of problem. It is desirable the image corresponds to values of the task. According to the generated task parameters, the images have to be generated as well.

In the article (Gangur, 2011a) an automatic generator of questions and answers is described. The universal principle of the automatic parameterized questions generation was explained. The generator algorithm generates random input parameters of question according to particular problem constraints. At the same time, the generator solver calculates and generates responding answers from input parameters according to problem solution. The outputs of the procedure consist in creating questions meant to be imported to a question bank and/or in creating a set of randomly selected and automatically created questions for the whole test. Both outputs can be generated within the demanded structure suitable for the applied system.

The output of the task generator is an Extended Markup Language (XML) file in the universal proposed format that is possible to transform into the format of the selected Learning Management System (LMS) Moodle (Moodle, 2010) by means of a particular question template and LaTeX (LaTeX, 2013) versions of the test, consisting of randomly chosen and randomly generated problems. According to the applied dictionary, the question can be generated in different languages. The current version of the generator is able to process tasks in Czech and in English.

The generated questions, after they are translated in the Extended Stylesheet Language Transformation (XSLT), are suitable for the import into different formats, for example into LMS Moodle, PDF or AcroTeX interactive PDF format (AcroTeX, 2014) as a quiz with variants both for students (without a solution) and for teachers (with a solution).

The generator allows processing a question requiring a numeric answer, a question with a short answer and a question with a multiple choice answer. The generator processes numeric data, text or table as a data type of input parameters.

This contribution introduces a new feature of question that can be processed by the generator, i.e. automatically generated parameterized images. The new feature of such question is the possibility of an automatic insertion of the generated image object to the text of task. The new data type can be employed in the text question as variable input parameters and they can also be applied as part of the answer primarily as the options of the multi choice questions.

In the following part, the method of generating an image object is presented on an example of Matlab functions (MathWorks, 2013). The consecutive processing of the generated image object is explained. In this process, the integration of the object into the output XML structure is described and the following transformation of the object into the Moodle XML format of the question bank or into the text in a PDF file is presented as well.

## Related works

Automatic generation of questions has been dealt with in some specific areas. In (Cristea & Tuduce, 2011) the questions were generated in the area of electrical circuit analysis; another study focuses on question generation in the area of the object-oriented programming (Hsiao, et al., 2008). The problem of math/science tasks generation is addressed in (Ugurdag, et al., n.d.). The authors generate multi choice questions in the process of image modification by means of a developed graphic tool. In this process of image modification, new values of parameterized questions are not generated automatically. Automatically generated test questions directly from a chosen text can be seen as a special issue in this direction (Zeng, et al., 2013). Contributions dealing with this topic concentrate mainly on generating questions from the English texts (Sung, et al., 2007). Automated creation of adaptive tests with regard to the level of the knowledge of individual students is an independent field in which intensive research is being carried out (Kapusta, et al., 2010).

The above mentioned systems generate only text questions in a basic question type with numerical, short or multi choice answers. In the same way, the data types of input variable parameters are of numeric types or text types. None of these above mentioned systems provide the possibility of inserting the images that are connected with the dynamically generated content of questions. The author is not aware of any available

other resources containing solutions of this problem. The majority of the above stated tools as well as other examined instruments generate only online web tests.

In this contribution, such features of the question generator are introduced. The process of generating dynamical images dependent on other generated content of questions as well as the way of transforming the questions with images into different output formats are explained.

## GENERATING PROCESS

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The process of transforming the generated questions into the demanded output format is described in (Gangur, 2011a), (Gangur, 2011b). It consists of two steps.

1. The questions and correct answers are generated in the selected software (Matlab, Mathematica, ect.). The description of the generated questions and all their parameters including the answers in the universal XML structure are thus obtained.
2. The XML description of questions is used as the input to the XSLT process. In this phase the questions are transformed into the required final format according to the XSL template (Holzner, 2002).

The first step is explained with respect to the newly defined tags of the XML structure in the following section. These tags describe the whole information about the generated image, i.e. the image file location. The image is saved in the base64 code.

The image is created first. The following example of the program code in Matlab demonstrates the creation of the image with handler `f`, followed by the creation of a randomly generated histogram and finally saving the image to the temporary file with a randomly generated name from function `tempname`. In this example, the histogram is interconnected with the text of the question via the output parameters of `Create_Histogram` function. These parameters, such as the mean, modus and max\_frequency describe the main characteristics of the generated distribution and they are the basis for the generated parameterized text in question.

```
[f,ax]=Create_image(width,height);  
...  
[mean,modus,max_frequency]=  
Create_Histogram(ax);  
...  
ok = Save_image(f,tempname);
```

Listing 1: Creation of image (Source: own)

This process yields a temporary image file. The file is the source for the following generation of XML tags that become part of the output XML definition of the question.

The generation of XML tags with the image information has to take into account the requirements of different formats of the image information for different final output formats. For example, the generation of PDF files accepts only the image file name, but on the other hand, the Moodle XML format (MoodleXML, 2013) demands a complete base64 code of the image. All information is embedded in the form of sub tags in the main tag `<image>`. This tag describes the image placed in the text question or in the subquestions.

The possibility of inserting images to subquestions allows for the construction of multi choice questions, which in particular options, consist of images. The following XML structure demonstrates the result of the described tags generation.

```
<image name="tp48922464_23aa.jpg">
  <Base64File>.....</Base64File>
  <tmpname>
    C:/.../Temp/tp48922464_23aa.jpg
  </tmpname>
</image>
```

Listing 2: XML tag of image description (Source: own)

The tag `<image>` contains the information about the image file name, the file name with the path to the directory of the temporary files and complete base64 encoding of the image. This code is located in the `<Base64File>` tag.

The base64 image encoding is performed by a built-in function. When the applied software does not have such a function, any external library or external Java class commons-codec-1.10 (Commons, 2013) can be used. The used Matlab software allows for the use of such external Java classes.

The location of tag `<image>` in the XML structure of a question (Gangur, 2011a) is handled last. The simple solution is the location of a tag in the question text inside the tag `<text>`. Such a solution also supports a simple XSL template in the consequent transformation. In the transformation process, the image tag position is identical both in the `<questiontext>` tag and in the `<answer>` tag. It contains the answer text in the `<text>` tag, and the text of the answer can contain the image in the multi choice questions. The image information will be placed in different parts of questions with respect to the demanded final format. For example, the image is placed at the end of the question text in the Moodle XML format. In such case, the information in the tag `<answer>` is accessible in the text of answer or can be accessed from the `questiontext` via XPath `./text/image`. In the PDF file, the image can be placed on the right side of the answers or multi choice options in the PDF output. In such case the information in the tag `<answer>` is accessible from the answer part via XPath `../questiontext/text/image`.

The image is described in the XML structure for every question or sub question and the XML description is generated as the output of the first step of the whole process. The second step transforms the generated questions into the demanded final format by means of XSL templates.

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## TRANSFORMATION PROCESS

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The created XML file with the description of questions including the information about the images is the source for the XSLT transformation process. XSL templates manage this process with respect to the transformation rules. This section proposes templates transforming the image data from XML file into the final formats. The examples of Moodle XML templates and LaTeX templates are presented here. We construct similarly the templates for other formats.

The proposal of such templates consists of two tasks.

1. Definition of templates for inserting images
2. Placement of the image into the structure of the whole question. This task has to be solved by modifying the completed templates meant for transformation of particular question parts (question text, answers etc.) (Gangur, 2011a).

### Inserting of an image

The code for inserting an image is different for each output format. The following template of an image tag shows the rule for creation and insertion commands when LaTeX (AcroTeX) format is used.

```
<xsl:template name="image">
  <xsl:param name = "figure" />
  <xsl:if test="$figure">
    \includegraphics[scale=0.6]{<xsl:value-of select= "$figure
    /tmpname"/>}
  </xsl:if>
</xsl:template>

<xsl:template match="image">
</xsl:template>
```

Listing 3: XSL template for image transformation into LaTeX (Source: own)

The LaTeX (AcroTeX) command demands the name and the path of a temporary image file from the image information. Use of temporary files limits the use of the output LaTeX (AcroTeX) file with respect to time limitations. The LaTeX (AcroTeX) source would have to be used for fast PDF file generation. The template with the name `image` generates a LaTeX code for inserting the image. The second empty template matches all image tag occurrences in the source XML file and it eliminates its listing. The following LaTeX (AcroTeX) code results from the transformation.

```
\includegraphics[scale=0.6]{C:/.../Temp/tp48922464_23aa.jpg}
```

Listing 4: Transformed LaTeX code (Source: own)

Moodle XML format demands more information about the image including encoding the content of the image file. The final Moodle XML code consists of two parts. The first one is an HTML code for inserting the image into a web page. The second one is the code for loading the image into Moodle repository. This part has to contain the content of the image to be encoded. Both codes have to be generated in different parts of the question and that's, why two templates `ImageHTMLCode` and `ImgFileCode` are implemented. The empty match rule eliminates the processing of other occurrence of the image tag in the source XML file. The following two templates create such codes.

```
<xsl:template match="image">
</xsl:template>

<xsl:template name="ImageHTMLCode">
  <xsl:param name = "figure" />
  <xsl:if test="$figure">
    &lt;p&gt; &lt;img src="@@PLUGINFILE@@/
    <xsl:value-of select="$figure/@name" />"
    alt="Obrazek" /&gt; &lt;/p&gt;
  </xsl:if>
</xsl:template>
```



```
</xsl:if >
</xsl:template>

<xsl:template name="ImgFileCode">
  <xsl:param name = "figure" />
  <xsl:if test="$figure">
    <file>
      <xsl:attribute name="name">
        <xsl:value-of select="$figure/@name"/>
      </xsl:attribute>
      <xsl:attribute name="encoding">
        <xsl:text>base64</xsl:text>
      </xsl:attribute>
      <xsl:apply-templates select="$figure/Base64File" />
    </file>
  </xsl:if >
</xsl:template>

<xsl:template match="base64File">
  <xsl:copy>
    <xsl:apply-templates/>
  </xsl:copy>
</xsl:template>
```

Listing 5: XSL template for the image transformation into Moodle XML (Source: own)

The following Moodle XML codes are the result of the transformation. The two parts described above can be resolved. The tag Base64File contains the encoded image.

```

<file name="tp48922464_23aa.jpg" encoding="base64">
  <Base64File>
    ...
  </Base64File>
</file>
```

Listing 6: Transformed Moodle XML code (Source: own)

The final formats of codes will be generated and placed only in the required positions and they will not be placed in the position, where the image code is placed in the input XML file. The determination of just one occurrence of the resulting image code according to the context dependence of the template calling is possible by means of the above mentioned template (see Listings 3, 5). The template doesn't match all the occurrences of the image in the XML file. This feature is provided also by the second empty match rule image in listing 5.

## Placement of image

The modification of templates for the image placement in any part of the question is explained in detail in this section. The rules for the image placement are located in the templates that transform the question parts where the images have to be placed. These rule differences in XPath refer to the image tag. This reference depends on the relative position of the calling rule and on the position of the image tag in the source XML file. Two different examples are presented. In the LaTeX (AcroTeX) format, the image is placed on the right side of the answers or of the multi choice options. That's, why the image

template code is inserted into the template for conversion of the answer part of the question. In this case, the answer part is divided into two columns. One is for the answers or multi choice options, the other one for the image.

The following template code shows the transformation rules into a LaTeX (AcroTeX) format.

```
<answers>
  <xsl:if test=" ../questiontext/text/image">
    \begin{minipage}{0.48\textwidth}
  </xsl:if>
  ...
  <xsl:if test=" ../questiontext/text/image">
    \end{minipage}
  \begin{minipage}{0.48\textwidth}
    <xsl:call-template name="image">
      <xsl:with-param name="figure"
        select=" ../questiontext/text/image" />
    </xsl:call-template>\end{minipage}
  </xsl:if>
</answers>
```

Listing 7: Part of the template answers with calling of the image template (Source: own)

The first part of the template code is located at the beginning of the answer template and it opens two environment columns when the image tag exists in the question definition in the XML file. The second part closes the first column, which is created in the answer text or the multi choice options and it opens the second column into which the image is inserted. We implement this insertion as the calling of the image template with one parameter that refers to the image tag in the XML file. The images are also inserted into particular options of the multi choice question when the options contain the images, for example in a multi choice question. In such case images are simply inserted only into one column and the calling rule refers to the image tag with respect to the tag position in the text inside the tag `<answer>`. The following modification of `answer` template shows this solution.

```
<xsl:template match="answer">
  <xsl:choose>
    <xsl:when test=" ../ ../@type='multichoice'">
      \vspace{1mm}
      <xsl:if test=" ../ ../single='true'">
        $\scriptstyle\bigcirc$ \hspace{3mm}
        <xsl:apply-templates select="text" />
        <xsl:call-template name="image">
          <xsl:with-param name="figure" select="text/image" />
        </xsl:call-template>
      </xsl:if>
    </xsl:when>
    ...
  </xsl:choose>
```

Listing 8: Part of template answer in multi choice question with calling of the image template (Source: own)

Similarly, the image code is placed in the Moodle XML code. The image is inserted at the end of the question text on the web page of the question in Moodle. That's, why the template `ImageHTMLCode` for HTML code generation is called in the text template. The advantage of positioning the XML tag of the image in the source XML file is utilised here.

The tag is located in the text of the question or in the text of the answers in the multi choice questions and this is the reason why the HTML code is generated right here. When the text doesn't contain any image tag (for example the name of question), calling of ImageHTMLCode generates empty space.

The information about the content of the image file for loading into the Moodle repository has to be placed into another position in the question. The template ImgFileCode is called from questiontext template after closing tag of the question text. The image tag reference is different from the calling in text template according to the tag position inside the tag <text>. The following code defines the part of text and questiontext templates with calling of the templates.

```
<xsl:template match="text">
  ...
  <xsl:copy>
    <xsl:apply-templates/>
    <xsl:call-template name="ImageHTMLCode">
      <xsl:with-param name="figure" select="./image" />
    </xsl:call-template>
  </xsl:copy>
</xsl:template>

<xsl:template match="questiontext">
  ...
  <xsl:call-template name="ImgFileCode">
    <xsl:with-param name="figure" select="text/image" />
  </xsl:call-template>
  ...
</xsl:template>
```

Listing 9: Part of template questiontext/text and questiontext with calling of the image templates  
(Source: own)

The modified templates are used for the generation of questions including images.

---

## EXAMPLES OF QUESTIONS

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In this part the results are presented using two examples. Both examples are the results of the generation process following from the template of the multi choice question text.

The figure shows distribution of points of evaluation among students of selected group. The average of population is ##average## points. Check what statements are ##correct\_incorrect##.

The variable parameters are average and correct\_incorrect. The last one formulates the question as positive or negative. The above described process randomly generates the image of a histogram with respect to the parameter average. Then it randomly generates the numeric values and words of predicates less or more according to the distribution of the histogram. These numeric values and predicates are inserted into the generated statements in particular options of this multi choice question. The result of the generation phase is a universal XML file that describes the question including the correct answers (Gangur, 2011a). The image information is part of this XML file. In the second phase, the XSLT process transforms the question from XML file to the required

formats LaTeX or Moodle XML with respect to the applied XSL templates. The last step is a PDF file creation from LaTeX source or the insertion of a Moodle XML file into the Question bank in LMS Moodle.

The figures present the results of the generation and transformation processes. The first Figure 1 shows part of the PDF file as a result of the question generation in the LaTeX format. The Figure 2 depicts the same question generated by means of different, randomly generated input values and a different, randomly generated image as a question in a Moodle course.

1. (1 point) The figure shows distribution of points of evaluation among students of selected group. The average of population is 50 points. Check what statements are correct.

Check answers.

- ☐ Average of points of group is more than modulus of group
- ☐ 25 students have 20 points.
- ☐ The result of group in exam is substandard
- ☐ Average of points of group is more than 50 points

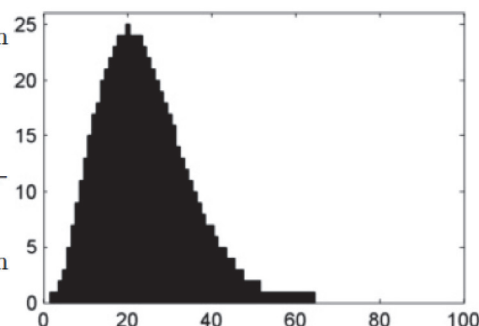


Figure 1: The result of the question generation in PDF file.(Source: own)

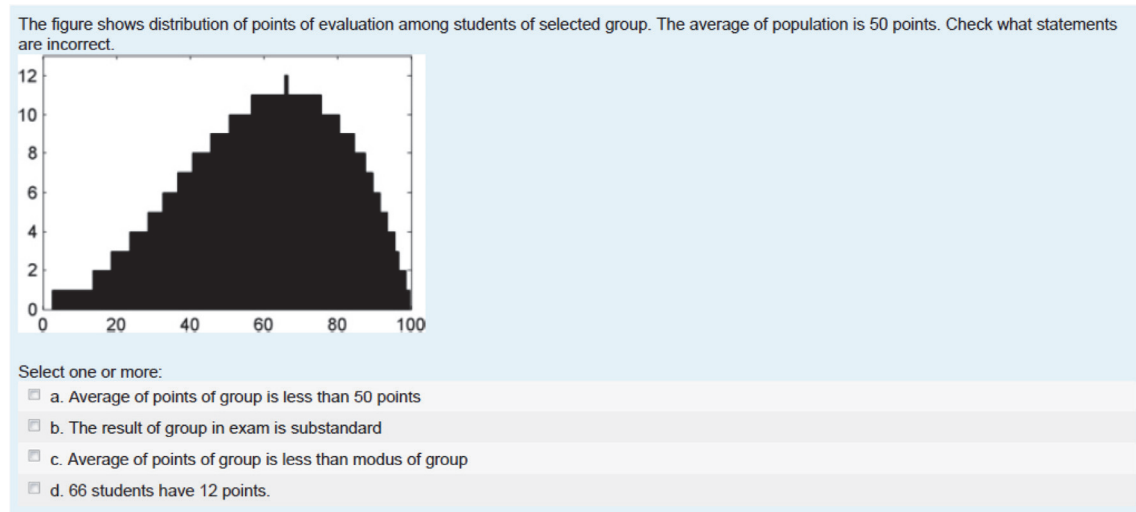


Figure 2: The result of question generation in Moodle.(Source: own)

It is possible to generate any number of questions with randomly generated images and responding values in the question text or the texts of particular options. The generator allows building up the question bank from any number of questions that are generated from one template. In the same way, the generator can generate any number of test variants and prepare them in the PDF format.

## CONCLUSION

---

The described methods describes the random generation of images interconnected with the generated values of the parameters in the question text or in the text of the answer options. In this way, the image can be one of the data types of the input parameters appearing in the question text as well as numeric, text or table data types.

In practice, the generator has been used specially for producing statistics problems. For example, we have created 185 tasks from the area of statistics using this generator, which resulted in 15,000 unique problems generated according to these patterns. The automatically generated questions are also used for students of the distance learning courses in management science (Gladavská & Plevný, 2014). Other tasks of operational research contain e.g. randomly generated spanning trees figures or figures of feasible region of the LP problem that has to be described with linear inequations (Plevný & Gangur, 2016).

All these problems constitute the bank of tasks implemented in the LMS Moodle (Moodle, 2010) functioning as support e-courses. Moodle XML was selected as the output format of transformation for the Moodle question bank. In the same way, the tests for the written exams were prepared from different tasks. The final tests in PDF format were generated in any number of variants.

The described solution also supports the insertion of an external image that is common for all the generated questions. Such image is one of the input variable parameters, such as the image data type. The name of the image file is inserted into `<image>` tag and then it is processed in the same way as the randomly generated image.

We can generate randomly the images not only in the Matlab system used in the instance described above. A question with images can be prepared in any other system and then it can be transformed to the universal XML output format. On present, we develop a library of transforming functions for Mathematica system. At the same time, we search the possibility of cloud SaaS (Software as a Service) solution to make generator functions accessible for other users.

The proposed solution extends the possibility of presenting questions. Especially in such courses as statistics, the figures help to understand the characteristics of different types of distribution according to the shapes of distribution or density functions. By the same way, the data in the graphs on the figures allow to identify for example the problem of correlation. The automatic generation of tasks with different figures allows the students to practice not only with one set of input values with corresponding figure or figures, but it gives them the possibility to practice the same problem on a large number of variants. The description of a problem is more illustrative as it helps to understand the problem and this way it improves the quality of the learning process.

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# Virtual Dissection as a Digital Technology Application Used in Education - from the Results of Research Studies

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## Abstract

*Digital applications increasingly pervade almost all human activities including education. We can notice a higher frequency of computer simulation implementations in education of biological, medical and pharmaceutical areas, e.g. real dissection alternatives, which still represent a traditional part of experimental activities in these areas. A computer dissection simulation, alias virtual dissection, provides in some aspects comparable and often better study results than real dissections. Despite this, pupils and students evaluate lessons using such modern teaching aids quite sceptically because they are influenced by a number of factors. One of the most essential factor is represented by teachers who still prefer real dissections. In our research study, we deal with the analysis and presentation of research results focused on implementation of the real dissection and its digital alternatives in biology, science subjects, and for comparison in medical and veterinary areas. We also focus on students' and teachers' attitude toward these applications and the effectiveness of such applications in education process. The research study results indicate that dissection alternatives are unable to replace adequately the real dissection. As a result, reasonable combining of both seem to be most effective.*

## Keywords

*Education. Teaching aid. Simulation. Virtual reality. Virtual dissection. Dissection. Research studies.*

---

## INTRODUCTION

These days science education does not focus only on knowledge and practical skills, but also on the ability to discuss and think critically. These skills are also enhanced by a sensible application of methodological tools including experimental activities. In areas of



biology, it is the real dissection that is seen as an experimental activity allowing to explore the internal anatomy of organisms through laboratory activities using real organisms or parts of them.

Carrying out dissections pupils and students gain a better understanding of individual organs, their location, appearance as well as their function. Let us consider a question whether it would be possible to replace these techniques by less invasive applications or more human methods. Balcombe (2000, p. VI) says: "Of course it is wonderful to learn about the amazing complexities of even simple creatures, to learn more about the way they work, but there are many other ways in which children can obtain this knowledge." Science tries to describe the world around us using special methods, with the help of which science also tries to express and generalize observed phenomena. It is new technologies enabling implementation that operates on the principle of simplification and creating model situations that suppress irrelevant events and emphasize characteristics (Volf, 2012). For this purpose, we use ICT providing a virtual environment which enables innovative learning, and to a large extent which can reduce the fear of failure and allow more creativity (Puhek et al., 2013).

Can computer simulations completely replace real dissections? What are teachers' and their students' attitudes toward a virtual dissection?

## **COMPUTER SIMULATION AND THEIR IMPLEMENTATION IN EDUCATION**

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A virtual dissection is in most cases a computer simulation that models the inner anatomy of organisms by using interactive computer programs (the term does not apply to static pictures, movies or animations not allowing an active interaction of the teacher with the computer). Computer simulations belong to data sources enabling to explore any phenomenon that is limited for experimental approach, and are used in almost all areas of human activities, particularly scientific, economic, social and medical areas. In scientific knowledge, simulations serve as a tool to validate theories, test and evaluate conceptual models, data analysis, process control in real time, visualization and animation of real systems and processes, detailed studies of dynamics and experimenting, as well as they can serve as a heuristic tool in the process of postulating hypothesis and new theories (Hubálovský, 2011, Machková and Bílek, 2013, Balogh et al, 2015).

We can define simulations in different ways, e.g.: "Computer simulation is a computer-implemented method for solving process models, in which the process is so complex that it cannot be implemented using other tools (Hubálovský, 2011)." Simulations are characterized by the ability to change values and variable properties, as well as to observe changes. Obtained data can then be processed and classified.

Computer simulations are used to replace real systems in case of a danger resulting from manipulation with a given system (radioactivity, the effect of toxins on organisms etc.), then in case a given system does not exist or is part of an elusive dimension (space, molecular level of organisms), in case any manipulation in the given time interval is impossible (evolution of organisms), or experiments are unethical etc. We can also simulate experiments that are impossible to carry out by way of traditional procedures. Such simulation experiments, like formation of galaxy, formation and evolution of life on Earth, evolution and extinction of species, spreading of diseases, cell membrane transport

mechanisms, etc. are used to detect consequences in case a developed theoretical model is too complex. In the course of the use of simulations there is also a considerable risk of bias because simulations work only with selected pieces of information and interferences are therefore largely eliminated (Volf, 2012)

A simulation can be considered as an important didactic tool (Mašek et al., 2004), which allows a better understanding of the presented processes and systems (e.g. in biology - fusion of gametes, cleavage of embryos, structure of cells, etc.). In many cases simulations serve as a cheaper and faster option, despite the fact that many teachers accept them sceptically due to having no experience of their own (Chen and Howard, 2010). Therefore, it is necessary to include simulations in the future teachers' training at colleges and universities, including biology, since new teaching tools are meaningless if teachers do not recognize their value. What teachers say is that there is not enough time to use ICT, there is a lack of money, or teachers themselves are not sufficiently computer literate (Puhek et al., 2013). Despite all that, results show that computer simulations raise pupils' motivation and activity, and therefore they are more efficient in achieving the objectives (Chen and Howard, 2010). Through computer simulations pupils and students themselves have the possibility to carry out experiments and explore things, especially if the education process proceeds real events and actions. Theoretical teaching itself using computers is much more interesting for pupils and students while the main benefit is cost and time saving (Fazal et al., 2012). If students are allowed and encouraged to formulate their own hypotheses and to check them through simulations, then understanding theoretical knowledge is much more effective (Singh et al., 2011). Following the conclusions of the studies, we can say that computer simulations develop skills by way of identifying problems, finding, organizing, analysing, evaluating their solutions and presenting information. Computer simulations used within researches themselves represent complex processes allowing users to interact with a dynamic model of a system and to create their own procedures leading to more effective learning.

3D computer models are also a suitable supplement tool not only in science subjects providing a perfect insight into the studied object. Consider teaching anatomy where such models provide realistic views of the entire body or various organs without having to gain killed animals. Pupils and students accept 3D models positively (Tan, Waugh, 2013), because using them they remember the subject matter much better (Havlíčková and Bílek, 2015), yet it depends on how the models are used (Ioannidou et al., 2010). On the other hand, using these technologies, their full potential referring to the social aspects of learning, is not fully exploited. In order to integrate these aspects, it is suitable to use so-called collective simulations (Ioannidou et al., 2010). Their involvement is an important aspect of social learning, during which each participant has a role. A collective simulation runs in real time within a network of interconnected computers. This is so-called a two-level simulation (the first level is individual - individual decisions of an individual, the second level is a collective level - visualization of all decisions transformed into one place). An example of such a simulation might be "Mr. Vetro" program, which makes students perform individual tasks to achieve the main objective while teaching physiology and the human body (Ioannidou et al., 2010). "Mr. Vetro" contains complete lesson plans, worksheets, other supporting materials etc. Studies have shown that students studied more actively, interlinked new and old information, postulated and then tested their hypothesis, and thus they have achieved comparable or even better learning outcomes. Helikar et al. (2015) studied students' activation and creativity while working with a

computer application created by using the web platform called Cell Collective. The study shows comparable results in understanding, long-term remembering information, developing critical thinking and others. The users are place-independent, because thanks to the Internet they can interact with each other over a long distance. This simulation helps blur boundaries between education process and research, and thus increases motivation towards the study of the area. Chen and Howard (2010) describe computer simulations developed by Challenger Learning Centre, which use distance learning technologies (the Internet and videoconferencing). Through this, students have the opportunity to gain experience in interactive learning, during which they use found information in order to solve problems on the basis of a predetermined scenario. These simulations positively affect the tendency towards further studies of sciences (Chen and Howard, 2010).

Virtual environment can be also used in science educations as a virtual tour connected with fieldwork (Puhek et al., 2013). The research studies reveal the fact that it is women who prefer virtual tours, but all respondents agreed that virtual tours do not fully replace real tours. In the Czech Republic Šibravová (2014) dealt with the efficiency of fieldwork and its alternatives in the form of virtual tours. Her result also show that virtual tours cannot fully replace the real ones, because they could cause students' lack of interest in nature and their own environment.

Schools miss suitable study materials that would exploit visualization (Tan and Waugh, 2013). According to the results, it is computer visualization thanks to which students reach better study results in learning molecular biology in comparison with traditional learning using textbooks. Visualization supports understanding, increases students' interest and involvement. Without visualisation students learnt only through memorising which could not guarantee understanding of various cellular processes (Tan and Waugh, 2013). Many students were motivated by simulations to further studies of molecular biology and biology itself in the general meaning of the word.

## **COMPUTER SIMULATIONS IN BIOLOGY EDUCATION PROCESS OR VIRTUAL DISSECTION**

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The main source of information about the morphology of animal bodies is just a dead animal. As many of the authors stated, the doctrine of dead bodies is a complex experience, because the dissection cannot be easily quantified and evaluated. Its mission is to prepare pupils and students for the actual practice.

Studying the issue connected with dissection education applications and especially their alternatives, is a relatively neglected topic comparing the Czech Republic with other countries. In terms of alternative dissections researchers deal with the study of pupils' and students' attitudes primarily towards computer simulations as the most spreading alternative (Havlíčková and Bílek, 2015). Balcombe (2000) indicates their advantages that are: the quality and appearance of the material, work at your own pace, activeness, getting back to previously watched parts that would normally be irreversibly destroyed, then information and descriptions of observed structures, feedback, time and space independence, time lengthening or shortening, change in parameters without an animal being exposed to jeopardy, lower costs, simplification of the education system, the

possibility of individualized learning, eliminating confusing and side effects like not using animals etc. Lots of other research studies deal with the effectiveness of such teaching tools (Havlíčková and Bílek, 2015). For instance, two-thirds of university students in Sydney agreed that real and virtual dissections are beneficial when learning anatomical structures and their functions (Franklin et al., 2002). In addition, interactive dissection of a cat provided better academic results in comparison with a real dissection. In this research, students preferred and favoured a procedure that they could experience on their own. Most negative responses referring to dissection concerned this activity specimens (segmentation and relative age). Secondary school students and university students evaluate instruction using computers as better (Balcombe, 2001) and the virtual dissection helps pupils achieve higher scores in didactic (progress or achievement) tests than the traditional dissection (Alley et al., 2009). As the results indicate, both types of dissections can be combined to achieve the best possible educational results. Better results from virtual dissections are achieved also thanks to the possibility to avoid nausea caused by odour and blood (Predavec, 2001). Balcombe (2000) also shows similar results in effectiveness of computer dissection alternatives. Cross and Cross (2004), however, revealed the complete opposite. In their study, they achieve better learning outcomes with pupils carrying out the real dissection. Virtual dissections have not only their supporters but also opponents. One of them is Allchin (2005), who understands a virtual dissection as a game leading to ruthlessness and insensitivity. According to Valli (2001), the virtual dissection does not help develop and gain certain specific manual skills, e.g. hand-eye coordination.

## **VIRTUAL DISSECTION AS PART OF DIGITAL MATERIALS FOR LEARNING ANATOMY**

---

The real dissection does not necessarily have to be included in the education of pupils and students who will require specific manual skills in their future occupations. Therefore, computer dissection alternatives could be implemented in the process of teaching anatomy to implement, once they are already relatively easily accessible (Balcombe, 2000). In the United States, there exist organizations that lend computer dissection alternatives. This way it is possible to get more than 100 CD-ROMs, videos, 3D models, etc. only for the price of postage. A similar borrowing system is expected to introduce in Europe and Australia (Balcombe, 2000).

One of the most popular digital applications in this area is HyperMedia – the atlas of dissections, which is designed primarily as a teaching aid for secondary schools, and which also includes a test of knowledge achieved (Quentinbaxter and Dewhurst, 1992). Predavec (2001) in his study also works with a similar interactive dissection simulation of a rat, which contains a combination of visual materials, video, text, animations and a didactic test. Valliyate et al. (2012) similarly analyse simulation software of a dog abdominal cavity used for training and practising diagnostic techniques (gastroscopy, colonoscopy, cystoscopy and operation laparoscopic surgery).

Langley also dealt with computer dissection alternatives, he also Langley (1991) who analysed the use of Ratstack (virtual dissection - interactive atlas of the rat dissection). This application allows to 'freeze' individual images in the screen, and thus work with them.

Balcombe (2000) mentions some kinds of virtual dissection that are available in the United States:

- Science Works: Dissection Works (earthworm, crayfish, fish, frog, pig, and cat)
- Pierian Spring Software: Bio Labseries (pig, frog, invertebrates [earthworm, crayfish, starfish], flies [genetics])
- Tangent Scientific: Dry Labseries (frog, lobster, grouper, rat, pig foetus, earthworm)
- Digital Frog International: Digital Frog, Digital Frog 2
- NEOTEK: Cat Lab
- Virtual Physiology Series (five CD-ROMs) covers the whole area of neuro-muscular physiology, simulates all traditional experiments performed by doctors, dentists, veterinarians, biologists, chemists and students
- Sim Bio Sys Physiology Labs using animations, simulations, exercises and quizzes covering general, cardiovascular, renal and respiratory physiology. Reproduces over 1,000 physiological parameters.

For teaching human anatomy Fazal et al. (2012) recommends the following tutorial software:

- A.D.A.M. interactive anatomy software available on the web interface,
- DynamicHuman 3D-DOCTOR (3D medical imaging software for 2D models from computer tomography (CT), magnetic resonance imaging (MRI) and microscopic images)
- Anatomy.t (the program enables to change the view, add and remove layers of 3D anatomy)
- Anatomy Explorer (BiotechVirtual, 3D anatomy software, which allows you to explore, identify and describe a gradual manner and qualitative characteristics, relationships, hierarchy and physiological processes of the human body)

Another useful software is the above mentioned Mr. Vetro that was created for the purpose of teaching human anatomy and physiology (Ioannidou et al., 2010). Interactive videodisc referring to the area was described in 1991 by Kinzie and Strauss (1991). In the Czech Republic it is Ondrová (2012) who created the atlas of dissections of invertebrate animals that contains photographs, descriptions of dissection procedures, laboratory work equipment etc.

Comprehensively, we have dealt with real dissection alternatives involving also virtual dissections in a research study which included the analysis of research studies on the use of real dissections and dissection alternatives in teaching biology, medical and veterinary areas (Havlíčková and Bílek, 2015). As a source of the research sample for this research study, we have used the Web of Science and EBSCO, and additionally data provided by Google. Using key words for searching in the Web of Science database we have found 12,328 references (up to 20<sup>th</sup> September 2014), and 1001 references in EBSCO database (up to 20<sup>th</sup> September 2014). As a result, 33 research articles have been elaborated and eventually resulted in the following findings. The analysis of research studies shows that the real dissection is in many cases not better than a number of available alternatives. Although the alternatives are ethically preferable, pupils and students evaluate their

learning process using alternatives rather sceptically. Teachers also prefer the real dissections because as they say pupils and students remember their first dissection long after it was carried out. However, pupils and students remember not information but feelings and emotions accompanying the dissection. In research studies, students gave the following arguments against dissections: they are terrifying, they felt sorry for the dead animals, emotional aspect, freshness of a material, nastiness etc.

From the elaborated studies we can say that the most developing and used alternatives are virtual dissections - 88 % (n = 33, see Table 1). Studies have paid less attention to realistic 3D models, and the third most common alternatives included video and image materials. However, these alternatives are according to a number of authors currently decreasing.

Table 1: Overview of cited dissection alternatives in analysed research studies (n = 33) (Havlíčková and Bílek, 2015)

Dissection alternatives	Virtual dissection	Modelling organs	Plastinated specimens prepared specimens	Real 3D models	Figurines	Video tapes	Student self-study exercises	Experiments in vitro	Image material	Excursions	Using animal parts e.g. from slaughterhouse	Dissection of plants - as analogy
Frequency (%)	88	21	30	70	12	49	12	9	49	12	18	6

Dissection simulations and other alternatives arise most often for the group of mammals (see Chart 1), although students and pupils perceive macroscopic invertebrates as most detestable (Randler et al., 2013).

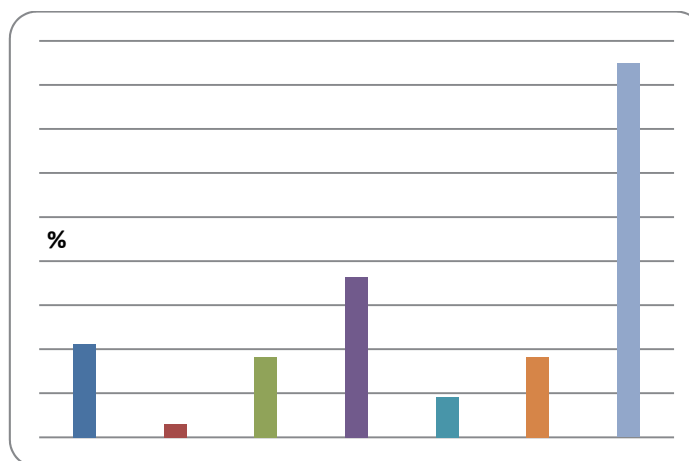


Chart 1: Focus of research studies on dissections and dissection alternatives in the area of education (n = 33). (Note: Majority of studies reported more species of animals or was focused on general research that is why it is impossible to get the sum of 100 %.) (Havlíčková and Bílek, 2015)

As the analysis of research studies shows that ICT are implemented in education more and more, and although they represent an important motivating factor for pupils and students that helps them understand some complex aspects on the one hand, teachers are

largely against their use. The full potential of simulations is not adequately exploited, and on the contrary some other important aspects of education tend to be neglected. Despite these facts, they provide comparable and often better academic results. They develop pupils' and students' critical thinking and they link theory with practice, thanks to what education is innovative. However, even these positive features fail to fully grasp reality, and therefore they should serve as a good instructional complements.

In today's schools and education the dissection has a different position than it used to have before. The attitude towards the ethics of dissections, lack of bodies and possibilities of modern devices seem to be in the centre of discussions. (Fančovičová and Prokop, 2014). Putting together more types of alternatives or a combination of both the real and virtual environments can significantly improve knowledge of anatomy.

## CONCLUSION

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The current trend in biology education areas is the implementation of computer-based alternatives. In general education regarding learning objectives, we can assume an increasing proportion of virtual dissections (computer simulations) accompanied by reduction of real dissections. Although dissection alternatives play an important role alongside real dissections, they are unable to replace real dissections completely. Pupils and students accept dissection alternatives with considerable reserve, prefer real dissections, and are mostly against a full replacement of real dissections to their alternatives. According to our findings, dissection motivates some students to study biology positively, while others negatively. In order to adopt dissections more widely, authors suggest to use "ugly" – not cute animals, to begin with the analysis of plants and indicate their analogy to animals, to use animals formerly intended for consumption, e.g. trout. On the other hand, they warn to implement so-called "cute animals" (cats, mice, etc.), which in turn increase the aversion to the study sciences.

Virtual dissection themselves do not make understanding of the anatomy of animals easier but they are an important tool for the study, and they can be an effective tool for preparation for real dissections or her feedback evaluation. Research studies show the fact that the virtual dissection provides in many cases comparable or better academic results, is financially more efficient, and has a number of positives in comparison with the real dissection. In conclusion, we can recall Balcombe (2001), who recommends and says that if we have an option between two modes of behaviour – the one that causes pain, suffering and death, or any other that does not cause pain, suffering and death, then our ethical principles dictate us to use the latter one.

## ACKNOWLEDGEMENT

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This paper is published thanks to the financial support of Specific Research of Faculty of Education University of Hradec Kralove 2016.

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# E-learning at Primary School - Case Study

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## Abstract

*The main goal of the paper is description of the possibilities of implementation of ICT into learning of selected subjects at primary school. The paper focuses mainly on the possibility of development of interactive e-learning materials in author system Hot Potatoes. The paper describes in form of case study the specific interactive e-learning material designed and created in the Primary School Bratří Čapků in Úpice. The creation of e-learning materials was supported by the project "Computer-aided preparation of pupils". In the first part of the paper there is introduced characteristic of where the school the primary e-learning materials have been implemented. The next part of the paper highlights the Moodle as the best learning management system for implementation of interactive e-learning material created in author system Hot Potatoes. The final part of the paper presents separate modules of the author system Hot Potatoes and the examples interactive learning material created in this system for primary learning.*

## Keywords

*E-learning. Primary education. Moodle. Hot Potatoes. Case study.*

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## INTRODUCTION

We live in a society with rapidly evolving information and communication technologies (ICT). The man gets into professional and social isolation without advanced ICT skills, without the ability oriented himself in new technologies and without quick adaption in new condition – Maněnová and Špilka (2014).

Multimedia increasingly influence life. The internet is an integral part of life. Over a relatively short period gained both internet popularity and number of internet users. The internet starts popular among increasingly younger users and so schools as educational institutions are facing a new reality (Šedivý, 2014). The introduction of ICT brings not only problems with the technical equipment of schools, but also need to increase the ICT skills of teachers and pupils – Maněnová and Burgerová (2013).

Elements of e-learning are used at all universities and increasing number of secondary schools. There are also primary schools that implement e-learning management systems with the aim increase the quality of their educational process. Information and communication technologies are used to support the cognitive processes and the social and psychological aspects of education. Teacher role is irreplaceable, but its role is changing. At the same time changes the form of learning materials - Maněna, Rybenská and Špilka (2015).

The paper describes in form of case study there the specific interactive e-learning material designed and created in the Primary School Bratří Čapků in Úpice. The creation of e-learning materials was supported by the project "Computer-aided preparation of pupils" within 6600 interactive e-learning materials were created by teachers of the school for subjects: Czech language, Mathematics, English and Nature – Hubálovská and Hubálovský (2015).

The project was based on assumptions confirmed by scientific studies, that:

1. Home preparation of pupils, particularly in primary education is integral part of the successful completion of individual subjects. The goal of homework is to practice the curriculum, developing pupils' sense of duty, to develop the ability to independently learn, get feedback on mastering the curriculum to teachers, pupils and their parents.
2. Children of school age spends on the computer in average 2,5 hours a day, but without increasing the 'right' ICT skills. They spend time in computer for fun in the form of games, social communication and downloading multimedia applications.

By combining the above-mentioned assumptions, the goal of the project is to streamline pupil's time spent with the computer. The project develops pupil's knowledge acquired in primary learning in the lesson and at the same time develops properly their ICT competence by the performance of e-learning homework prepared in the form of interactive e-learning exercises.

## **PRIMARY SCHOOL OF BRATŘÍ ČAPKŮ IN ÚPICE – CHARACTERISTIC OF THE SCHOOL**

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Primary school of Bratří Čapků in Úpice, is one of two primary schools in this city. The primary school had 13 classes with total of 298 pupils at academic year 2014/15. At the primary school there were nine classrooms with a total of 206 pupils. At the first stage there were 49 students with learning disabilities integrated into regular classes (Hubálovská, 2015). These pupils are taught according to individual educational plan. The autistic pupil was integrated in the fourth. This pupil had a personal assistant. Other three assistant of teachers helped with social disadvantages pupils. There were 25 of socially disadvantaged pupils mostly pupils from Roma families. The assistants of teacher worked with the children quite individually within the learning lessons. The homework are missing to pupils from socially disadvantaged families, so these pupils are lagging in basic knowledge. Teaching assistants take care of socially disadvantaged pupils also after school lessons, when they help to write their homework and practiced subject of matter.

All pupils had chance to visit one of the computer laboratory and practice their knowledge of school curriculum by Moodle system in which interactive exercises created in authors system Hot Potatoes are implemented – detailed information can be found in further text. The chance was mostly used by pupils from socially disadvantaged families. Only a few students from ordinary families used this chance. The primary school is equipped by school computer lab with interactive whiteboards. All classrooms has wifi internet connection. The computer lab is equipped by sixteen notebooks. This number of notebooks is not entirely satisfactory, because there is more pupils in the classes in the primary stage and whole there were two possibilities of learning in the computer lab. The first possibility is divided the class to two groups. The second possibility is that some pupils from whole class are working in the pairs. Both possibilities were used.

The pupils are learned based on educational program “Blahováček” (that corresponds to the Framework of Education Programme for primary schools) at primary school of Bratří Čapků. Despite the fact the subject Information and communications technology is introduced in the fifth class of the school (In this course, the pupils learn basic concepts (hardware, software), basic computer control (turn on, turn off the computer, using a mouse and keyboard, computer handling, etc.), as well as the pupil become acquainted with the basic fundamentals and editors work on the computer; these are the expected outcomes in the fifth grade), the project "Computer-aided preparation of pupils" allowed the pupils grade acquainted with computers from the first class. The pupils during using the school Moodle and interactive e-learning material train their skill turn on and turn off the computer, train the ability to work with a mouse, computer keyboard knowledge, train their knowledge log into the school computer and log into the school Moodle. These skills, ability and knowledges the pupils have to get within the subjects Czech language, Mathematics and Nature in which they practice with interactive e-learning materials.

### Moodle at Primary school of Bratří Čapků

Within above mentioned project "Computer-aided preparation of pupils" the Moodle LMS was created at Primary School of Bratří Čapků, in which the e-learning materials for pupils of the school are implemented in. Homepage of LMS Moodle of the school is shown on the Figure 1.



Figure 1: Homepage of LMS Moodle of ZŠ Bratří Čapků in Úpice

Moodle is storage place and management system for e-learning materials created in author system Hot Potatoes. Hot Potatoes exercises are arranged by classes and subjects. Figure 2 shows ordering of the Hot Potatoes courses in LMS Moodle.

The Hot Potatoes e-learning materials are created directly by teachers of the primary school of Bratří Čapků.

The e-learning Hot Potatoes materials are created for subjects:

- Czech language, Mathematics and Nature for the first and the second class;
- Czech language, Mathematics, Nature and English for third, fourth and fifth class;
- Czech language, Mathematics and English for the sixth, seventh, eighth and ninth class.

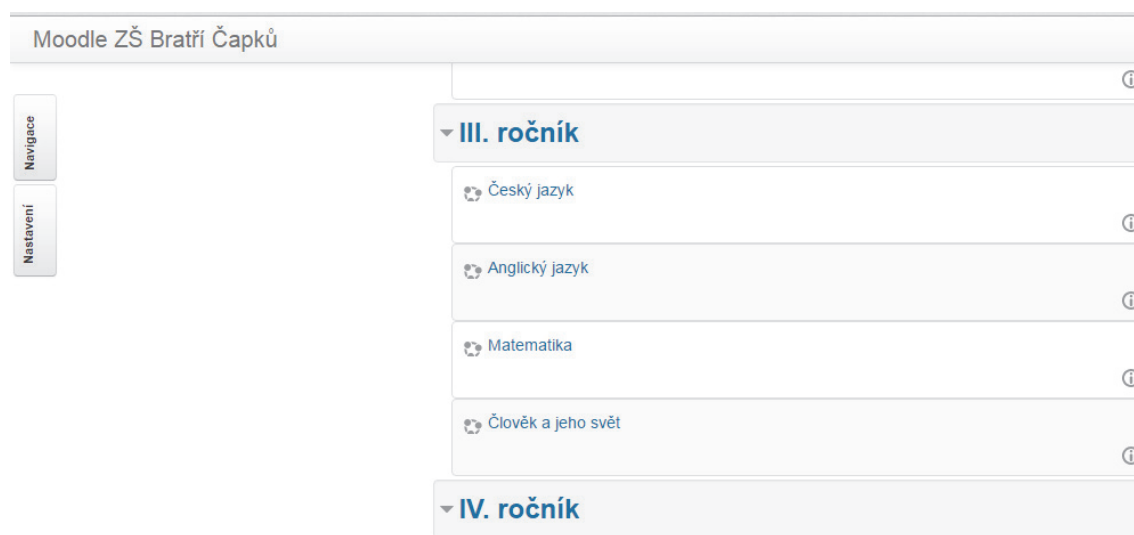


Figure 2: Ordering of the Hot Potatoes courses in LMS Moodle

The above mentioned Hot Potatoes materials are divided in each subjects into the individual topics. All topics of Hot Potatoes materials correspond to the school curriculum “Blahováček” and are classified according to the timetable school curriculum. Each topic is split down into separated tasks. The pupils are very well versed in this management system and they are able to perform e-learning exercises by themselves without any help.

The pupils of the primary school of Bratří Čapků are registered in Moodle according to the school year. The pupils can access the e-learning materials created in Hot Potatoes of given school year as well as the previous school year. The reason is that pupils can practice or repeat material from the previous class, that being forgotten and so on. Selected students, especially students with specific learning disabilities, or students from socially disadvantaged families have accessed courses two years back. Again, it is due to practicing or consolidation of curriculum.

Moodle allows management of e-learning Hot Potatoes exercises - records and stores important information on the performance of given e-learning exercises (for example saves the data on the success of the exercise performance in percentage, the number of attempts of the task, when the last access was realized, and how long the exercise was performed).

## HOT POTATOES EXERCISES – CASE STUDIES

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As already mentioned above the system Moodle is used for management of e-learning material created in author system Hot Potatoes. The author system Hot Potatoes enables creation of interactive e-learning exercises that can be executed not only in computer but also in new smart device like tablets, smart phones or interactive board.

The main advantages of this author system is that principle of design and creation of the interactive exercises is easy and intuitive and the exercises can be created by anybody who can work with computer standardly. The e-learning material in primary school of Batří Čapků in Úpice was designed and created by teachers of the school within the project "Computer-aided preparation of pupils".

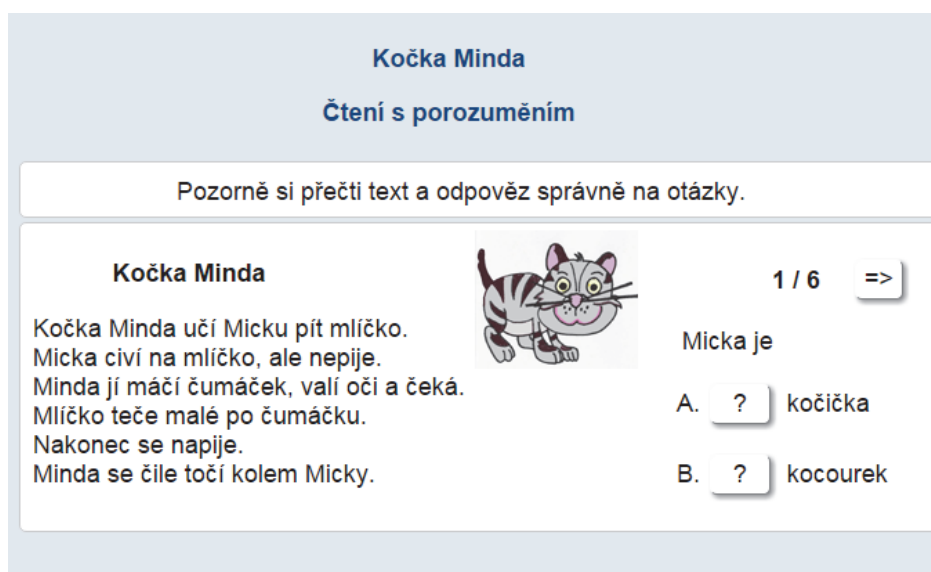
The author system Hot Potatoes enables creation of e-learning exercises of different level – for different age of pupils. In the primary school of Bratří Čapků v Úpici there were created e-learning exercises for pupils from the first class to last (ninth) class.

Hot Potatoes program consists of 5 parts (JQuiz, JCross, JCloze, JMatch, JMix), which allow you to create different types of exercises.

### Module JQuiz

Module JQuiz allows creation of exercises in which pupils are chosen one correct answer from the given options or they are chosen more correct answers from the given options.

The first example of JQuiz is exercise "Kočka Minda" – see Figure 3. This exercise is intended for pupils of the first class. This exercise is designed for practice of reading skills and comprehension at the end of the first school year when pupils are already able to read, understand and oriented in simple text. In the left part of the exercise window there is the text that the pupils reads. In the right part of the window the pupils answer the questions. A total of six questions examines whether pupils understand the text with comprehension.



The screenshot shows a Moodle JQuiz exercise titled "Kočka Minda" with the subtitle "Čtení s porozuměním". The instruction reads: "Pozorně si přečti text a odpověz správně na otázky." The exercise content is divided into two columns. The left column contains the text: "Kočka Minda učí Micku pít mlíčko. Micka civí na mlíčko, ale nepije. Minda jí máčí čumáček, valí oči a čeká. Mlíčko teče malé po čumáčku. Nakonec se napije. Minda se čile točí kolem Micky." To the right of the text is a cartoon illustration of a grey and white cat. The right column shows the question "Micka je" with two multiple-choice options: "A. ? kočička" and "B. ? kocourek". A progress indicator at the top right of the question area shows "1 / 6" and a navigation button "=>".

Figure 3: JQuiz exercise – correct answer

Other example of JQuiz is exercise named "Quiz for clever kids" – see Figure 4. The pupils choose multiple answers from the menu in this exercise.

Kvíz pro šikovné děti

Pozorně si přečti otázku a vyber správnou odpověď.

<= 8 / 10 =>

Označ všechny správné možnosti.  
Úpice přímo sousedí s těmito obcemi:

- a. ☐ Trutnov
- b. ☐ Batňovice
- c. ☐ Suchovršíce
- d. ☐ Havlovice
- e. ☐ Rtyně v Podkrkonoší
- f. ☐ Radeč
- g. ☐ Červený Kostelec
- h. ☐ Libňatov

Zkontrolovat odpověď.

Figure 4: JQuiz exercise – multiple answer

Another type of JQuiz exercise is based on complete correct short answers. In this type of exercises the correct answer has to be complete to the edit field. The question has to be asked clearly, so that the pupil should be able to add a short answer. In the example shown in the figure xxx the pupils have to add answer "yes" or "no". This exercises is for pupils of the third class, the subject Nature, topic My town – see Figure 5.

Kvíz pro šikovné děti

Již zodpovězené otázky: 1/10.

<= 10 / 10 Ukázat všechny otázky.

Zapiš odpověď.  
Je v Úpici nemocnice?

Zkontrolovat odpověď.

Pomoz mi, prosím.

Ukaž mi správnou odpověď.

Figure 5: JQuiz exercise – short answer

The fourth type of exercise JQuiz is exercise "mixed response". In this type of exercise pupils reply short answer. If they fail to answer correctly, the exercises becomes a type of answers "more right answers" – see Figure 6.

Figure 6: JQuiz exercise – mixed answer

## Module JCloze

Another module of Hot Potatoes is JCloze module. This type of exercise allows to create tests and optional exercises.

One option of the exercise is selection one correct answer from the drop down menu. Exercise shown in the Figure 7 is designed for first-class pupils for the subject Czech language. Exercise is intended to practice reading skills with comprehension. Pupils from the drop down menu choose the correct answer.

Figure 7: JCloze exercise – choose correct answer

Another option of JCloze exercise is to complete the correct answer into empty editing box. Example of this option exercise is shown on the Figure 8. The exercise is intended for pupils of the third class, for the subject Nature, topic Plants.



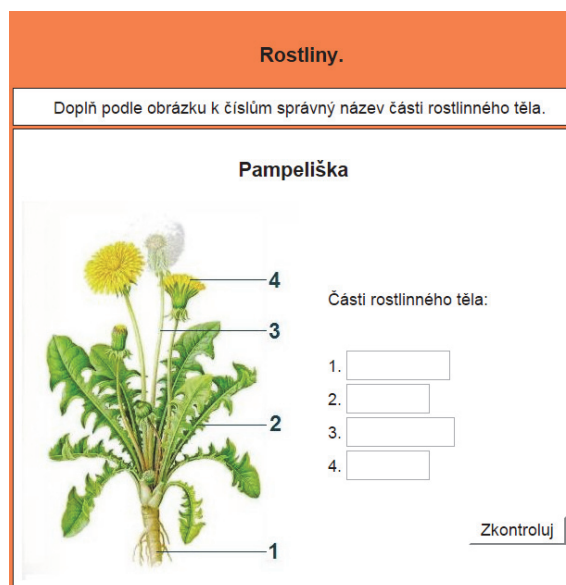


Figure 8: JCloze exercise – insert correct answer

## Module JCross

Another module of Hot Potatoes is JCross module. This type of exercise allows to create simple crossword puzzles. Example crossword puzzles exercises is shown on the Figure 9. This example of exercise is designed to practice colors in English for students of the third class. Pupil clicks on the number of enigma, the image of colors is displayed and pupil has to enter correct answer. The answer will appear on the crossword puzzle network.



Figure 9: JCross exercise – puzzles crossword exercise

## Module JMix

Exercise of module JMix are based on creating series, sequences, sentences etc. This module is suitable for the sort of words, images, etc. according to the rules. There are two types of exercise based on way of work with them.

In the first type of JMix exercise is "Drag and Drop", the pupil have to correct answer drag by mouse and drop it to the correct place – see Figure 10. Example of exercise shown on the figure is intended for first class pupils in subject Czech language. Pupils practiced reading of diphthongs in words. Their task is to sort pictures in the same order as the words are entering.



Figure 10: JMix exercise – Drag and Drop

The second type of JMix exercise is "Click". Pupil just click by mouse to correct answer, and the result automatically moves into proper place – see Figure 11. The example shown on the figure is from English. Pupils practice their English vocabulary - numbers from one to twelve. Pupils has to click in prescribed order to pictures on numbers and the pictures are automatically ordered in defined location.



Figure 11: JMix exercise – Click

## Module JMatch

Exercises of module JMatch are “allocation” exercise. There are two types of JMatch exercises-

The first type of JMatch exercises is "Drag and Drop". Pupils in this type exercise are struggling correct answers from the right column the left column – see Figure 12. Exercise shown in the figure is designed for pupils of the second class for the subject of Mathematics, topic Orientation in time. Pupils has to assign correct clock time to the digital time.

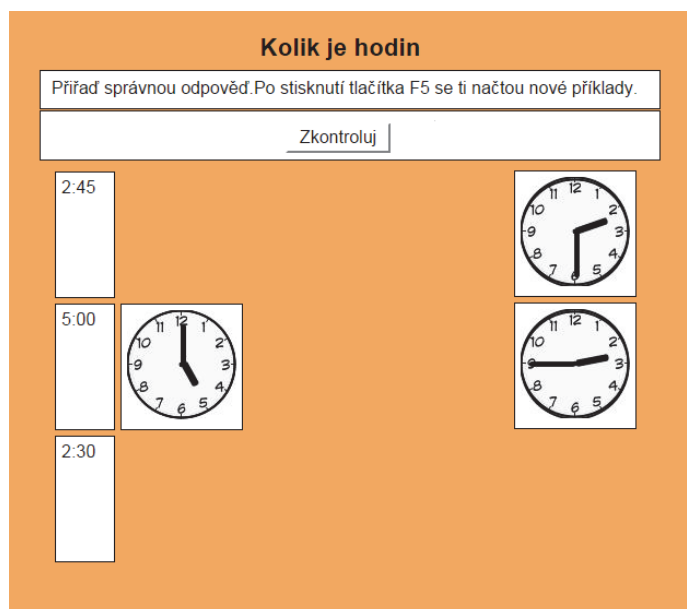


Figure 12: JMatch exercise – Drag and Drop

The second type of JMatch exercise "Selection menu". Pupils in this exercise choose the correct answer from the drop down menu – see Figure 13. Exercise shown on the figure, is designed for pupils of the second class, subject Mathematics, topic multiplication by three. As clear from the figure the pupils choose the correct answer from the drop-down list.

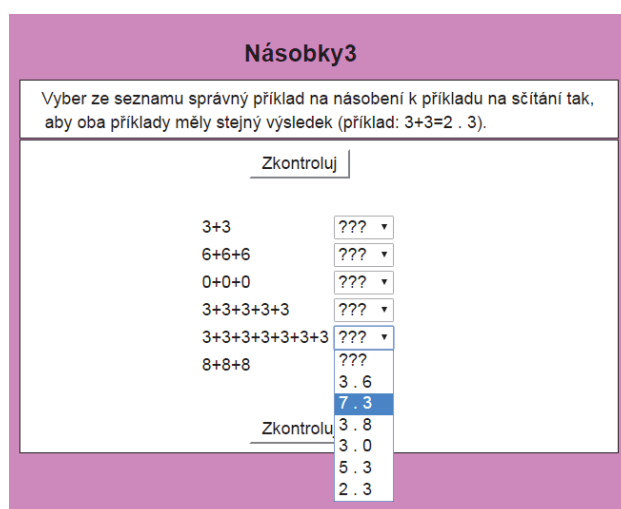


Figure 13: JMatch exercise – Selection menu

JMatch module allows create exercises of type "Pexeso". Example of "Pexeso" exercise is shown in Figure 14. The example of "Pexeso" exercise is intended for second

class pupils, subject Nature, topic meadow. The pupils practice basic knowledge of plants and animals.



Figure 14: JMatch exercise – Pexeso

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## DISCUSSION AND CONCLUSION

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The effectiveness of implementation of e-learning materials at primary stage of primary school has been already discussed in Hubálovská (2015a) and Hubálovská (2015b). The already presented results shows that the use of e-learning materials at primary stage of primary school:

- increases pupil's motivation of the subject;
- increases pupil's interest of the subject;
- does not improve pupil's grade in the subject;
- increases pupil's ICT competence;

The results of the research confirm positive influence to development of pupil's individuality, pupil's ability, knowledge and pace of pupil's work.

From the teacher point of view, the positive influence of using of e-learning materials in primary stage of primary schools is as follows:

- E-learning represents a diversification of educational process;
- It enable intensive training of the curriculum;
- It enable individual pace of pupil's work;
- E-learning helps to pupil's with ADHD;
- Own design and creation of materials in Hot Potatoes increases ICT competency of teachers.

Only the basic types of exercise are described in the paper. The creators of e-learning exercises of author system Hot Potatoes have countless opportunities to apply their

creativity and create interesting, attractive and stimulating learning materials. We have to say that the teacher of primary school of Bratří Čapků in Úpice succeed in realization of the above mentioned project "Computer-aided preparation of pupils". All the exercises that were created within the project are inserted into school Moodle. All the exercises adjust not only pupil's age, but they also match the school's educational plan.

## ACKNOWLEDGEMENT

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This paper has been supported by: Specific research project of University of Hradec Kralove, Faculty of Education in 2016 and Specific research project of University of Hradec Kralove, Faculty of Science in 2016.

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# Towards the Implementation of Mobile Technology into the Experimental Chemistry Education

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## Abstract

*One of the ways, how to integrate the information and communication technology into the chemistry education, is the video recording of chemical experiment. A number of authors or teachers is devoted, on a professional level, to the video recording of chemical experiments as an example of usage of the educational video record. Anyway, how the record of a chemical experiment would look like from the perspective of pupils using the mobile technologies during laboratory work? In this article, we give the case study examining the influence of changes in organizational conditions on the level of mobile technologies use in education according to The Substitution Augmentation Modification Redefinition Model (SAMR model). Specifically, the contents and formal quality of pupil's chemical experiment video records were examined. 29 pupils of the fourth year of eight-year secondary education aged 14 to 15 took part in the case study. They were monitored during three two-hour laboratory exercises under the guidance of their chemistry teacher with long experience. The pupils were asked to solve the assigned laboratory tasks and at the same time to process their video recording using a tablet, in one case without the specific instructions and in two other cases with exactly given instructions. The method of structured interview with the teacher and pupils, and analysis of video records of their products accompanying laboratory activity were used in the case study. The results show that appropriately selected instructions lead to a higher level of the mobile technology integration into educational process according to SAMR model.*

## Keywords

*Mobile technologies. Video record of chemical experiment. The Substitution Augmentation Modification Redefinition Model. The case study.*

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## INTRODUCTION

The use of information and communication technologies (ICT) in education is, because of their ubiquity in everyday and work life, a part of education strategies. In the Czech Republic, it is the so-called Digital Strategy for Schools until 2020, which as its priority objective sees the opening of education to new methods and ways of teaching with the

help of digital technologies (ICT), the improvement of digital and ICT skills of pupils and the development of their informatics thinking (MŠMT, 2014). Strategies of ICT incorporation into schools include, of course, also the financial support for these activities usually, e.g. from the *“Education for Competitiveness Operational Programme”* (ECOP), which is co-financed by the European Social Fund under the jurisdiction of the Ministry of Education, Youth and Sports (MŠMT). This programme involves several calls. In connection with equipping schools with the new ICT, let us mention the call No. 51, which enables e.g. purchasing of 20 mobile touch devices for each participating school, or the sub-programme *“EU Money for Secondary Education”* where the key activity is the *“Innovation and Improvement of Education Through ICT”* (MŠMT, © 2000-2016). As a result, new technologies such as interactive boards, tablets or voting devices can be found more often in schools. There are many ways of using these technologies in the classroom, even with regard to the different requirements of various subjects (Machková, Bílek, 2013; Bílek, et al., 2011; Chroustová, Bílek, 2014 and others). In this article, we are focusing on one of the possibilities of using tablets in chemistry education, the video recording of chemical experiment – in our case, performed by pupils as a part of their laboratory activities.

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## TABLETS AND MOBILE TECHNOLOGIES IN SCHOOLS

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“Mobile learning projects are blooming all over Europe. They range from the use of Personal Digital Assistants (PDAs) and tablet computers in classrooms, through mobile phones to support learning between schools and museums, to context-aware technology for field trips and tourist visits.” (Walker, 2006)

The growing use of such technologies is illustrated by a number of studies dealing with the integration of mobile technologies into education (Fojtik, 2014; Sheng, et al., 2010), with the attitude of teachers and students toward using these technologies (Montrieux, et al., 2015; Van Praag, Sanchez, 2015), with the effectiveness of education supported by the mobile technologies (Boulind, et al., 2014; Mitu, 2013), etc. Researches on teachers and students' perception of using the tablets for education and study purposes (Montrieux, et al., 2015) show that the teachers can be divided into two groups. The first one uses the tablet only as “a book behind the glass” and the second one uses the tablet in an innovative way. If the innovative approach is used, the education process changes to learning-concerned approach. According to this study, tablets facilitate the transition from “learning by heart” to learning through multimedia, social media and the integration of personal world of children, which makes learning much more meaningful. How the mobile technologies change the way of learning is documented by the study, according to which the tablets enable so-called “here and now” education. It is based on an instant access to information through mobile technologies, with respect to the authentic activity of pupils in relation to their learning (Martin, Ertzberger, 2013). Mobile technology is also transforming other aspects of education, not only “the explanation” in terms of getting information, but also the testing of pupils gradually changes from traditional paper method to the mobile technology (Moldovan, 2015).

There are several methods of the incorporation of mobile technologies use into education. The first one is the use of one device by more pupils (sometimes denoted as 1:N). A lot depends on the number of available devices. It can be only one device, usually owned by the teacher. In such case, it can be used for recording auxiliary videos, taking

photos or projecting images using a data projector. If there are more devices, it is suitable to use them for group work. The use of information search is applicable in this case (Hubalovsky, Hanzalova, 2015).

The second method assumes that each pupil can use one tablet (sometimes denoted as 1:1). The first example can be the so-called "BYOD" (Bring Your Own Device). Most pupils (especially from lower secondary education) own a mobile technology and can use it very well. Problems may be, however, caused by different operating systems (iOS, Android or Windows) and therefore also by the absence of a specific application. Purchasing of devices (usually tablets) directly by school is supported recently. As already mentioned, various grant programmes exist for this purpose. The school has several options how to use tablets. Lending tablets to pupils is the first option, the least common. The advantage is that the pupil has his/her own tablet also for the home preparation. The financial responsibility or spending time playing games belong, however, to the disadvantages. Static or mobile classrooms are more common. Pupils go to the static classroom to use tablets there, which enables the group work or project education. A charging box, which can be moved, represents the mobile classroom. The tablets can thus be used not only in school premises (regular classrooms, special laboratories or gym), but also outside the building (e.g. during instructional trips). (Vzdělání na dotek, © 2013)

The integration of mobile technologies into education can be shown using the so-called SAMR model (see Figure 1), which considers four levels of new technology integration with varying impact on the changes in education. At the lowest level, the new technologies are used just as a substitute for traditional media, no new functional elements are brought into education. On the contrary, at the highest level, the new technologies are integrated into education so that they have a vital and irreplaceable function there (Goodwin, 2012).

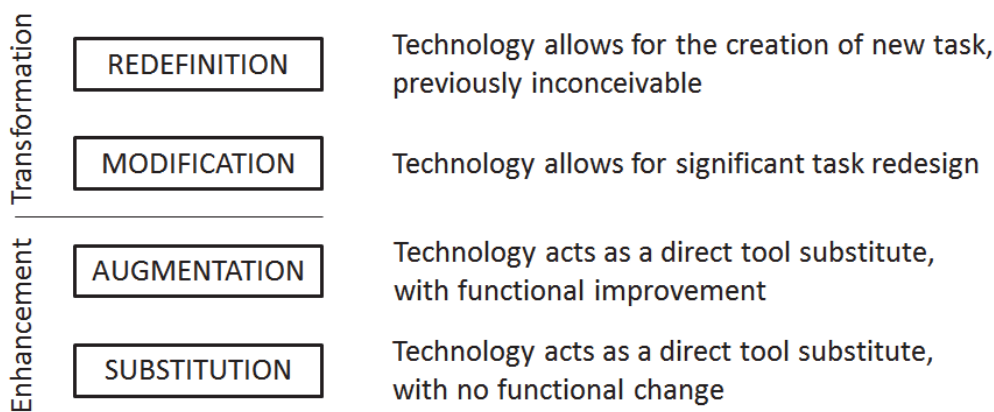


Figure 1: SAMR Model of Technology Integration (adapted from Goodwin, 2012).

Mobile technologies are often used in practice for the information search, for work with applications, for taking photos and audio or video records. Mobile technologies are also often used in education natural science for recording and processing of data measured during the experiment.



## VIDEO RECORDING IN CHEMISTRY EDUCATION

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The use of video records in education has a long history, as evidenced e.g. by the article "*Význam školních filmů a diafilmů pro uskutečňování polytechnického vzdělání žactva středních škol*" (in English "*Importance of school films and diafilms for implementing polytechnic education for pupils of secondary schools*"), by Auerswald (1953). The beginnings of school cinematography appeared in our country already in 1936 (Auerswald, 1953). First, the pupils could get acquainted with the video records in the form of educational films or filmstrips that usually had an explanatory function. The video records are mainly used in situations, where the static image, the spoken word or a separate sound are not sufficient for the visualisation of a certain action or process: during the capturing of an action or process, e.g. manufacturing etc. Another reason for the integration of video records is the effort to make the subject matter more attractive for the pupil or to pass more information to him/her within the shorter amount of time.

The use of video records plays also an important role in chemistry education. The video record can be used as a substitute for the instructional trips, if the manufacturing process is recorded in a specific factory, or as a substitute or a supplement to the real experiment. The video recording of chemical experiments allows us to present pupils with a specific objects, otherwise they would not have the opportunity to watch it. This includes dangerous, too expensive, time consuming and detrimental to the environment experiments, or experiments that cannot be run due to the inadequate school equipment (Keusch, 2004). The video record can be also used as a complement to the real experiment, whose course is too fast to be noticed by the pupils, or too small and its details cannot be seen by the pupils from the back desks. It is also a quick way how to summarize the experiment, or a safe way how to demonstrate the incorrect practice in laboratory (Keusch, 2004). Last, not so common alternative is the immediate recording and transmitting of the chemical experiment, and it is used in two ways. Either it serves to point out a certain part of the apparatus or detailed chemical reaction, at the same time allowing checking of the whole apparatus, or it enables the transmission of an experiment run in another place (Budiš, 1991).

An interesting classification of how to integrate video record in chemistry education is stated by Michel, et al. (1999), who see video record as:

- an integral part of pupil's multimedia laboratory report, which replaces the paper report and provides the teacher with more information on experiments performed by pupils,
- an important part of research based education, where the video record can mediate new perspective for pupil's understanding of scientific concepts,
- a report on instructional trip,
- the precursors for pupil's laboratory experiments, or instead of the demonstration experiment,
- a guide for laboratory activity,
- a recording of laboratory work,
- as a measuring tool (used more often in physical phenomena).

The video records of laboratory work recorded by pupils are an important source of information for the teachers and themselves. Such records can be used as a source of errors in laboratory work, as information on what the pupils pay attention to and also can serve as feedback for the pupils. Video record taken by the pupil of chemistry also maintains the laboratory skills of pupils. E.g. the pupils will make a video record during pipetting and after watching it with the teacher, and they get the feedback on their skills (Towns, et al., 2015). During laboratory experiments, it is possible to use the combination of pupil's own video records and the record from laboratory seen from the point of the third party, to capture more complex processes in laboratory lesson (Galloway, Bretz, 2016).

### **Practical Aspects of Video Recording by Pupils**

Video recording during lessons is already quite common in practice (Bull, Bell, 2009; Bell, Bull, 2010; Kaur, et al., 2014). The pupils' presentations are very often recorded in foreign languages – then mistakes and pronunciation are evaluated (Cakir, 2006). Shooting video records in other spheres of education is not an exception, where the outcome may be e.g. a song, or a clip. It is most commonly used as a feedback for the pupils or the teacher (Beacher, et al., 2014).

Before we start to record videos in lessons, it is necessary to think about the organizational conditions. First, devices for recording have to be purchased. In case of a video record used mainly for educational purposes, a quality mobile phone or a tablet would be sufficient. If we would like to edit the video record into a publishable form, the use of a camera is more appropriate. When recording, it is also necessary to pay attention to the audio component of the video record. The sound can sometimes be omitted and replaced by subtitles, but sometimes the sound is the most important component – then a quality microphone, acoustics of rooms and other factors have to be considered.

Another thing to consider is organization of work, whether it will be done in groups (more recordings all at once) or individually (recording of one video). We always have to consider the location of recording, the equipment needed the sufficient space or if the use of a tripod is advisable. The teacher also should check the technique in advance and learn to control it perfectly in order to avoid possible problems.

If the recording will be conducted only by pupils, it is advisable to prepare specific requirements and, at least, briefly introduce the rules of recording to them. The following requirements can be determined for recording experiments (Budiř, 1991):

- the recording must document the experiment,
- it must keep the logical structure and reflect the real course in time,
- details are to be chosen appropriately,
- the record must be simple and understandable,
- sound effects must be recorded appropriately.

To make a quality video record (clip), it is necessary to have a scenario first (Daněk, 2009), and to have suitable equipment and conditions (M. Krřka, 2013). Creating video records of chemical experiments is described in detail e.g. by Hanuliakov (2013).

In addition to providing technical and organizational issues, the legal norms have to be met as well. Not only during the presentation, but also during the actual video

recording from education, the applicable laws of the Czech Republic must be observed. Especially the Act No. 89/2012 Coll., the New Civil Code and the Act No. 40/1964 Coll., the Civil Code, specifically on the permission to acquire and publish images, and video and audio recordings, and the Act No. 121/2000 Coll., the Copyright Act, specifically on the consent to the use of copyrighted works (Nrodní centrum bezpenjšího internetu, 2014). Although some exceptions exist for schools (e.g. the records can be reasonably used as scientific material, but the pedagogical purpose is not stated), it is advisable to always have the signed consent of a pupil, in case of his/her minority, the signature of a legal representative. The so-called informed consent is recently submitted for signature to parents after their child is admitted to school, where individual points are carefully listed. This consent (or disapproval) can be changed by a parent at any time during school attendance.

The advantage of video recording in education is the possible interdisciplinary connection. The recorded material can be used in computer science (work with video record, editing, inserting of opening images or subtitles), in foreign language teaching (translations of texts to create subtitles) or in mother tongue lessons (stylistics or speaking exercises).

In the case study, we focus on the use of tablets within the chemistry laboratory exercises on lower secondary grammar school for a pupils' record of the solution of laboratory tasks, and the subsequent creation of the educational video records published on the school website. Therefore, the interdisciplinary connection of chemistry and computer science is realized. The case study observes and describes the impact of changes in organizational conditions on the quality of pupils' work and their video records.

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## **CASE STUDY**

### **Initial Conditions**

Chemistry lessons supported by mobile technology in the fourth year of the eighth year-class-gymnasium (this corresponds to lower secondary grammar school) were observed by case study. The ages of pupils were period 14–15 year. The chemistry has been educated in this class in second year. The class was divided into two groups. Always one group took place also laboratory work beside the classic chemistry lesson the laboratory work once in 14 days. The group compositions were following:

- Group A: 6 girls, 8 boys. One of them participates in a school round of Chemistry Olympiad.
- Group B: 5 girls, 10 boys. One of them participates in a school round of the Chemistry Olympiad.

There are study results in chemistry of pupils and average values of particular groups in the following table (1 is the best grade, 5 is the worst):

Table 1: Results in chemistry of the pupils.

	Grade	1	2	3	4	5	Average
<b>Group A</b>	<i>at the end of the 3<sup>th</sup> year</i>	8	4	2	0	0	1,57
	<i>in the 4<sup>th</sup> half-year</i>	5	7	2	0	0	1,79
<b>Group B</b>	<i>at the end of the 3<sup>th</sup> year</i>	7	6	1	0	0	1,57
	<i>in the 4<sup>th</sup> half-year</i>	4	9	2	0	0	1,87

All observed classes had been conducted by a certificated teacher with 13 years of practice in the education at a gymnasium. She has been accustomed to use ICT as auxiliary means for illustrations – presentation, quizzes and experiments in a video records. She uses an interactive panel minimally, but this is caused by an insufficient equipment of the chemistry classroom. She used the ICT during laboratory works in terms of this inquiry for the first time.

A sequence of particular phases of the inquiry is represented in the following diagram. After each of phases of “Video record production”, there followed a structured discussion to the teacher, a structured discussion with the group of pupils and an analysis of video records.

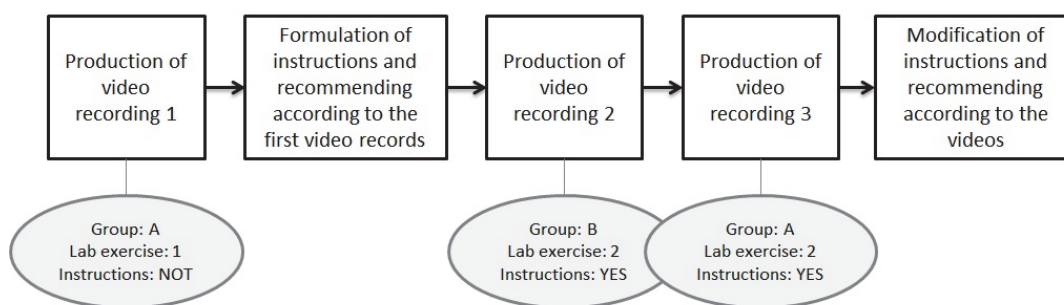


Figure 2: Diagram realization of inquiry with usage of case study.

During the observed classes the pupils had implemented two of different laboratory works. Contents of laboratory exercises was following:

Laboratory work 1 had dealt with different compounds of Cu and their reactions. The goal consisted in performance of two separated experiments. At the first case there was a preparation of the cupric oxide and consequently ascertaining its yield. At the second case there was a performance of reactions of the copper sulphate with several agents in vitro. These tasks represented parts of a school round of Chemistry olympiad and acted as a preparation for the regional round of the competition. There should be recorded in the video record (1) initial substances, a procedure and a product of the preparation including comments of color changes during reactions, (2) color changes during reactions in vitro and their explanation.

There should be performed evidence of a presence of hydrogen and carbon in organic compounds (saturated hydrocarbon and cane sugar) in laboratory work 2. The laboratory work goal consisted in a performance of two experiments and by virtue of its watching explaining the hydrogen and carbon presence in substances under the experiment. In this case, there was a usual school task contained in a textbook “Basic chemistry 2” for elementary schools and lower years of multi-annual gymnasiums (Beneš, Lexová, 2004).

There should be recorded in the video record (1) burning process of the saturated hydrocarbon in a closed beaker, identification of products including explaining the carbon and hydrogen presence in the saturated hydrocarbon, (2) a procedure for apparatus arrangement, process of the cane sugar oxidation including explaining the carbon and hydrogen presence in the cane sugar.

## **Realization of Classes with Video Recording**

### ***Production of Video Recording 1***

The during the case study observed group had received the given laboratory work by usual way, in addition to the pupils received tablets with instructions to produce a video record of their laboratory work. The pupils have been become acquainted with operation of the tablets only in a short way with possibilities of other questions. I.e., the pupils had neither special instructions nor information in reference to a video record purpose.

The process of the laboratory work will be further described in terms of an interview with the teacher. Pupils did not have any problems concerning the tablet operation. First of all, they had some small technical problems (two of the tablets had incorrect settings of cameras and one of them switched off permanently). Because of that, the tablets were renewed. After it there were not any problems regarding technologies. The video record production did not affect the performance of the lab experiment itself. Tasks of pupils in the group were divided into pupils, i.e. who works with which (in this case there was added a role of "a cameraman"). The works were performed usually, the performance of the laboratory work had taken two class hours; a production of the video record did not affect the performance of the lab experiment itself.

During an interview with some pupils from this part of the class we found out that recording by means of tablets they found as an interesting diversification of the class. Using tablets neither increased demands on the pupil preparation nor affected the laboratory work performance. The video record production was a fun for them. They have perceived negatively only the initial technical problems and the wrong quality of the sound-track. Here it is necessary to remark that the chemical laboratory has wrong acoustics and at work of five groups with loud speaking pupils, the quality of the sound-track was really wrong.

The group A handed five "raw" video records over, which we have analyzed in terms of both technical and content performance, i.e. recording key information concerning the processed chemical experiments. From the technical performance point of view the records have had a low quality, they were fragmentary, often with quick movements of the camera and with unessential information. Comments in words were either missing, or without references to the chemical phenomena under records. Only two of the groups forwarded over records which would be able to process further. From the contents point of view, only one of the groups has recorded essential information concerning both of the given tasks. There was either missing or largely missing a record of one of the tasks at the other groups. There was not recorded the whole process of the chemical effects in the video records (initial substances - reactions - products), but only separated records of a change under process or a reaction result only. There would be very difficult to perform a reconstruction of the performed experiments from most of the video records, which

means that there is practically impossible to use them for a study material for pupils or a base for appraisals of laboratory exercises by a teacher.

### ***Formulation of Instructions to Video Recording***

By virtue of watching the recorded videos and due diverse recommendations in the literature (Budiš, 1991) we have established following instructions and recommendations for another processing of this inquiry. All the text which has been consequently given the pupils we have divided into four fields: a goal (what should be created), an instruction (what should contain video records), recommendation (how to handle the tablet camera in order to create video records of the best quality) and remarks. The pupils have received a text to read:

Table 2: Instructions.

GOAL:	<i>Recording a video record (or a set of video records) being able to processed by a computer and in such a way to create an educational video presented on web pages of a school.</i>
INSTRUCTIONS:	The video record should contain: - introduction (a presentation of a laboratory work subject), - requisite aids, - preparation of an experiment (arrangements of an apparatus, if necessary, preparing chemical substances), - experiment process, recording observable changes, - results and closing, evaluation of the experiment, - short description (in words, substituted by subtitles later).
RECOMMENDATION:	1. Video records are to be recorded in the tablet horizontal position (better displaying in its display). 2. The zoom (approaching) is not to be used - there should be better to record the video at initial settings - the resolution will be better. 3. Pay attention to a jitter of the picture (try to stabilize the tablet). 4. Do not perform any quick movements. 5. Avoid blind spaces (if you expect that nothing shall happen in a long time period, finish the video record). 6. Avoid unsuitable comments. 7. Do not record anything being not in connection with the existing experiment.
NOTE:	If a static picture is enough for an existing par, you can use a photo. Delete video records and photos that should not be processed further.

### ***Production of Video Recording 2***

Group B anticipated already to work with tablets. It was evident before launching work (forwarding tablets and instructions), when their competitive spirit was shown - we shall have better video records than group A). Instructions for recording having been given, they studied them and had taken them into laboratory with in order to be able consult them. The submission of the laboratory task had been made in a usually way.

The process of the laboratory work will be further described in terms of an interview with the teacher. The biggest difference compared to the first recording consisted in a scene preparation for recording by a video. Pupils paid attention to every shot and some of them they even recorded repeatedly. They had tried to comment what could they see in

the shot. Some of them had problems with their own appearance in the video record. Some of the groups tried to record in such a way in order not to be their faces seen. Because of the pupil big effort there was not time enough. The teacher was forced to stay with the pupils even during the break, because some people were not able to tidy up because of the recording, which means exceeding the two hours time limit of 15 minutes.

The interview with the pupils had taken place in terms of a focus group. The pupils agreed that it was very demanding to perform everything during to class hours only. Herewith they were very impressed and asked whether they will have another opportunity for it and if they could be allowed to perform modifications of video records themselves. They were sorry that there was a noise in the laboratory (due to other groups) and that is why the records' quality was wrong. Nearly all of them tried to make first-rate video records and confirmed that some of the shots were recorded several times. Much easier for them it could be if the groups could consist of several members (not two members only). Two of the pupils were interested whether they could bring their own equipment with to enhance their video record quality even more. As a response to a question whether they were strayed from the laboratory exercise performance due it the all of them agreed that certainly not, on the contrary, they were more concentrated on the experiments under process. They were forced to follow what would happen, even several times. As a whole they expressed their enthusiasm and interest in repetition of that.

Group B forwarded seven of "raw" video records over which we have analyzed again in technical performance and content point of view. From the technical point of view the video records have had a higher quality compared with the foregoing group. There was seen from the records a well-considered shots, more logical situation of the camera, the camera's movements were calm or the pupil used a static camera. Most of the shots brought essential information according to a well-considered scenario. Comment in words accompanied all the video records excepting small deviations concerning very detailed comments to chemical processes at the end. Practically all groups of the pupils forwarded over records which would be able to process further. From the contents point of view, only one of the groups has recorded essential information concerning both of the given tasks. The other group records were also very closely performed however all of them missed a record of the product identification at the second laboratory task. All of the groups recorded the whole chemical process (initial substances - reactions - products). The pupils sought a precise and professional expressiveness in their recorded comments. From the handing over video records it is possible to reconstruct the performed experiments and to use the performed record as a study material or an evidence of appraisal of the laboratory work along with analysis of mistakes in a laboratory technology.

### ***Production of Video Recording 3***

This group (A) has once worked with tablets. This time there were not any problems with the technical equipment (which the pupils already confirmed at the interview). In this case they were already given also a table with recommendations and instructions which they took into the laboratory with.

This group made the records in given time term according to the interview with the teacher. Compared to the first recording they were essentially quieter. The laboratory work itself was not too successful allegedly, because three of test tubes were broken

during the work and some experiments could not be visible enough. Otherwise the recording processed a similar way as at the previous group.

The interview with pupils was performed in the focus group form again. Firstly the pupils mentioned that the recording processed much better, because they worked with tablets for the second time already. At the same time they appreciated the instruction which had been very useful for them. Furthermore, they wondered who would work with video records further and if they could be seen anywhere (which represents a great difference compared to the first recording). It had occurred two kinds of replies to questions whether they would like to use tablets sometimes during laboratory exercises again. The first of them certainly wanted to record further. The first of them were not against that, however herewith they did not want to record in every lesson. One of the pupils also asked if it is necessary to speak a comment direct into the video record, i.e. whether could be possible to write it down by hand (or to add it into subtitles themselves during modifications of video records).

This group handed five "raw" video records over again, which we had analyzed in the same way as in the foregoing cases. From the technical point of view the video records had better quality in comparison with the first recording. In spite of that there were at one of the groups still quick movements of the camera, a wrong tablet positions and shots containing unessential information (which also corresponds with a nearly three times larger length of the video record compared to the other groups). The other groups recorded comparatively first-rate records with more focusing to details compared to group B. They had used more shots from diverse angles connected with more consistent presentation of the whole experiment. From the contents point of view, only one of the groups have recorded essential information concerning both of the given tasks, similar as at group B. Records of the other groups were closely focused on shots of the auxiliary equipment and chemical substances and the own process of the experiment, however they missed a product identification at the second laboratory task, some of them even the product identification for the first task. All of the groups recorded the whole chemical process (initial substances - reactions - products). A comment in words was missed at one of the groups only, which had probably planned to add it in subtitles. The auxiliary equipment and the process were closely described in words however the conclusion was not commented correct very often. The pupils sought a precise and professional expressiveness in their recorded comments. Four of the groups therefore had handed records over, which could be processed to a first-rate study material in the form of a video record of the chemical experiment as a whole. The records could be also used for an appraisal of the laboratory work with mistake analysis in the laboratory technical equipment.

## **CONCLUSION**

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Using case study we described and analysed chemistry lessons of two groups of pupils making video records of performed experiments under different organizational conditions during a laboratory exercise.

The group A which had not got any exact instructions for recording videos had according to expectation gave video records of poor quality over, which could not be used



for an education. The group B which has already worked with the instructions had created video records of bigger quality which could be after following processing used for the education and utilized them as a source of other information not only for pupils themselves, however for teachers as well. In terms of the technical performance, the pupils from this group had always used a stand allowing make static shots which had not been any ideal solution under the given situation. Some important details could not be seen in the video records and an observer was missing a total view of the chemical experiment. By virtue of this founding we supposed to complete the instruction table. The first quality video records had been created by the last recording (group A) in which the pupils were focused on both details and the total view. The comments accompanying the video records of the laboratory exercise 2 were comparable in group A and B.

Results of this case study have shown that more precise instructions concerning video recording, which was applied, are for creating first-rate records enough. We supposed another processing the created records in terms of informatics classes and their utilization as a study material for pupils. However it was found that such a way obtained video records represent a valuable source of information for analyzes of an laboratory work by a teacher. The teacher can see the comprehensive work of all groups including mistakes, which she/he is not able to master under a real situation. The lab work having finished, she/he can analyzed the video records with pupils and provide them with a feedback in scope of their laboratory skills and also in scope of their knowledge because of accompanying comments which could catch right chemical conceptions and also wrong ones. Other important information, which the teacher can ascertain from the obtained video records, represent a fact that pupils will be more focused on the experiment process that on its result. An identification of the products of chemical processes is oft missing in obtained video records and there had been completely ignored e.g. weighing chemical products. It appears from this that pupil did not observe them as an important part of a chemical process. It consequently leads to creating inaccurate or incomplete conclusions of a laboratory work. Recording is also motivating for pupils and they consider it as a welcome diversification of the lab exercises. If we determine a pupil into a position as a cameraman of a chemical experiment, we instinctively forced her/him to thought about more thoroughly. An application of the mobile technology for the video record of the chemical experiment is also connected with a deeper insight.

The study shows that not only the work with a tablet itself is sufficient enough but it is necessary to submit it correctly and in the ideal case to recommend different "recapturing" as well. At the first recording, when pupils did not know neither the goal nor instructions, we balanced on the third level of the SAMR model (shots cannot be neither further processed nor shared - there are unsuitable shots here, comments and video records have lower quality in total, they are not focused on the experiment directly). When pupils know the work goal (what should be an output, which is their work intended for), the video records have better quality and we can speak about the fourth degree of the ICT integration into an education (again according to the SAMR model). Suitable selected instructions are also connected with a higher degree of an integration of mobile technologies into the education.

It offers an extension of this study of other elements in the future as e.g. processing video records in terms of the IVT classes (cutting tracks, receiving sounds and addition of

subtitles) or watching already performed first-rate video records representing the chemical experiment before creating of the record itself.

## ACKNOWLEDGEMENT

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This paper is published thanks to the financial support of Specific Research of Faculty of Science University of Hradec Krlov Nr. 2104/2016 and Specific Research of Faculty of Education University of Hradec Krlov Nr. 2140/2016.

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# A User-friendly Tool for Modeling and Simulation of Discrete Event Dynamic Systems

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## Abstract

*Currently, there are a number of tools for modelling and simulation of discrete event dynamic systems. One of the most widespread tools are Petri nets, which allow in addition to verify a number of assumptions that are placed on the model (e.g. liveness, boundedness, etc.). In terms of user-friendliness, one of the main drawbacks of Petri nets tools is their primary purpose as the support of science and research. In this work is implemented the editor of Petri nets, which will be primarily designed to support teaching (classical and distant forms). The main differences from the classic tools are clarity and clearness for all phases of the life cycle of the with the tool. User-friendliness is about convenience and customization options in the course of the modelling, clearness including animation of the dynamics in the course of the simulation and unification and simplicity of the results of the simulation or verification.*

## Keywords

*Modelling. Simulation. Animation. User-Friendliness. Petri Nets.*

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## INTRODUCTION

One of the main shortcomings of the teaching associated with modelling and simulation of discrete event dynamic systems (DEDS) is a limited availability of tools for visual representation of the structure and dynamics of the modelled systems. In the framework of this work the set of all DEDS will be limited to Petri nets. For modelling and simulation (or verification) in Petri nets, there are many tools, which differ mainly in the size of the set of all functionality they offer. However, one thing they have in common is lack of effort on the user friendliness of the environment (Mishra, 2009, Shneiderman, 1997). Petri nets as a tool for modelling and simulation is used when teaching a series of subjects (e.g. Operating systems, Modelling and Simulation, Petri nets, etc.) and it is therefore appropriate to choose the tools with an emphasis on their user-friendliness. One of the most widely used tools for modelling and simulation of Petri nets is HPsim (Anschuetz, 2003), which offers a dynamic simulation of the behaviour of the network with user-friendly animation. Other tools are for instance WoPeD (Freytag et al., 2016), CPN Tools (Jensen et al., 2012) etc. Most of the existing tools can be found here (TGI, 2016). Since mostly all of these tools were primarily created for the purpose of science and

research, it seems appropriate to implement a tool that will be primarily developed as a tool to support teaching.

The aim of this work is to implement a tool for modelling and simulation of Petri nets with emphasis on user-friendliness, which was suitable for the classic teaching and distant education. At the same time, the tool will include all of the basic functionality required for teaching of subjects containing event dynamic systems (modelling, simulation, animation, verification, etc.).

Petri nets are a useful tool for modelling of discrete event dynamic systems (DEDS – Discrete Event Dynamic System), which are characterized by concurrency, parallel processing, synchronization and non-determinism. Their main advantage is the ability to precisely verify assumptions for a model. From 60s, when the Petri nets have been defined by Carl Adam Petri (Petri, 1962), their development grows to different directions. One way was defining new properties of the models that extend the verification powers of Petri nets, for instance, checking liveness, boundedness, reachability of particular marking (state) and many others. In addition, most of these properties requires a number of assumptions that limit the definition of Petri nets, for instance, for verification of most Petri nets properties is necessary to ensure that the net is pure (pure net), i.e. the net does not contain self-cycles. Other example can be that same algorithms work only with ordinal nets, i.e. the multiplicity of edges is equal to one (Murata, 1989). Another direction of development is the refinement of the Petri nets definition by adding new elements, which specify and simplify the modelling with the tool (but with less formality). An example may be timed and stochastic Petri nets, which allow to improve individual state transition by time complexity (deterministically (Zuberek, 1991, Holliday and Vernon, 1987) or stochastically (Ajmone Marsan, 1990)). Another example are coloured Petri nets (Jensen, 2009, Jensen et al., 2009), which combine Petri nets with other modelling language and thus significantly widen (and mainly simplify) the modelling capabilities of the Petri nets. The main disadvantage of this second direction is limited verification options, i.e. need to verify most of the assumption (properties) by using the simulation.

## **METHODS**

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The editor of Petri nets (Ibl, 2015) was implemented by using the C# programming language using the Microsoft .NET Framework 4.5. Specifically, the Windows Presentation Foundation (WPF) is used, which provides native support for hardware acceleration of graphics card. During programming is utilized the Model-view-view model (MVVM) architecture.

In terms of user-friendliness a comparison between selected existing tools and the newly implemented editor is provided. Attributes for comparison were determined by an expert.

## **RESULTS**

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Graphical user interface for implemented application illustrates Figure 1.

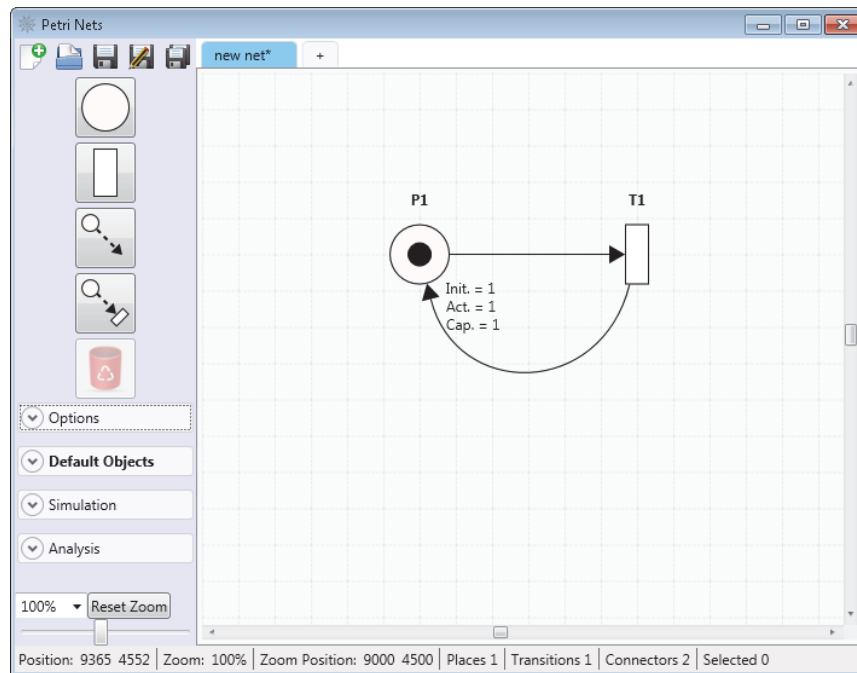


Figure 1 – The graphical user interface of the newly implemented editor of Petri nets.

The main window of the newly implemented editor consists of three parts:

- The left bar of the window contains the controls for working with the model (Petri net) and its objects (places, transitions and oriented edges). Namely these are:
  - A set of functional icons/buttons (top left), which allow to create a new network, open a saved network and three save options (the classic save, save as and save all open networks).
  - The buttons for the new place, transition, oriented edge (arcs), oriented edge including the new place or transition (depending on the type of starting node) and a button to delete any selected object/objects (places, transitions or oriented edges).
  - The editing options of the net (Options) and objects (Default Objects).
  - The options associated with the simulations (Simulation) and analysis (Analysis) of the network.
- Workspace for modelling can include grid, to which are places and transitions snap (grid size and transparency can be changed). Between different workspaces can be toggled by selecting the appropriate tab in the upper part of the workspace (clicking the name of the network).
- The status bar provides current information about: the position of the cursor over the workspace, the level of zoom in percentage, the position of the vertical and the horizontal scroll bar of the workspace, the number of places in workplace, the number of transitions in workplace, the number of oriented edges in workspace and the number of all selected objects.



Functional feature of this editor can be summarised into three categories, i.e. editing of network and its objects, simulation of dynamic behaviour and analysis of the behaviour properties of the network (boundedness, liveness, uncertainty, fairness, etc.).

## Editing network and its objects

Editing options of the network illustrates Figure 2. The editor allows to set the following properties:

- User workspace size (canvas) in pixels (width and height), the plot area is set at the centre of user workspace.
- Background colour of the workspace.
- The option to turn on/off the display the object names.
- The option to turn on/off the grid in the background with the possibility of setting its transparency and size.
- The option to turn on/off the use of capacities for places.
- The option to turn on/off the use of stochastic Petri nets.
- The option to turn on/off the display of thickness of oriented edges depending on its multiplicity (if its turned off, number is displayed instead).
- The option to turn on/off snapping of objects to the grid in the background.
- The option to toggle between the display of information (the initial number of tokens, the current number of tokens, capacity of places, the  $\lambda$  parameter of transitions and multiplicity of oriented edges) for all objects or only for selected objects or to not display any information.

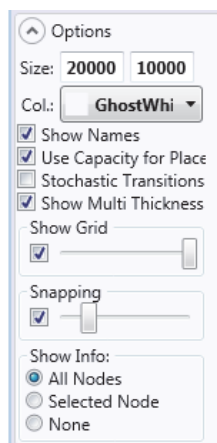


Figure 2 – Editing capabilities of the network.

The object of the network means the place, transition or the oriented edge. The menu for editing the object can be invoked by clicking (selecting) the object by the left mouse button. The places and transitions have the option to set their width and height, i.e. the place can possibly be a circle or an ellipse and the transition can be a square or a rectangle. Each object can be selected by clicking the left mouse button. For the selection of more objects simultaneously, it is possible to hold down the CTRL key and click on the next object or hold the left mouse button on the background (not on the object) and drag the mouse cursor over object that needs to be selected and release the mouse button. The places and transition can be moved by holding the left mouse button on the object and

dragging. Editing options of places illustrates Figure 3. It is possible to change the name of the place, its location, size (width and height), the number of initial tokens (can also be changed with the mouse wheel while pressing the CTRL key), the capacity of the place (only when the option for using capacities of places is turned on; can also be changed with the mouse wheel while pressing the SHIFT key) and its colour.

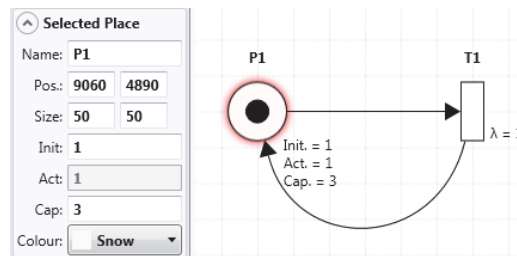


Figure 3 – Editing options of places.

Editing capabilities of transitions illustrates Figure 4. It is possible to edit the name of the transition, its location, size (width and height) the parameter  $\lambda$  (only if the option for stochastic net is turn on) and the colour.

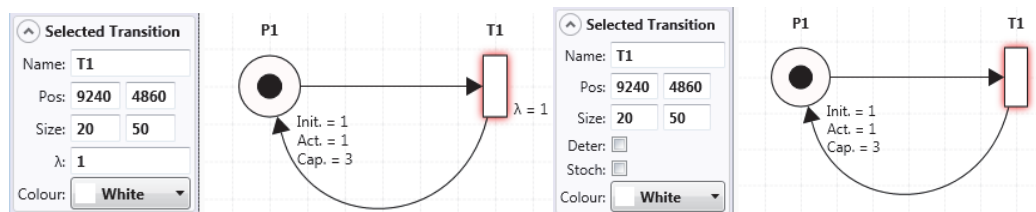


Figure 4 – Editing options of transitions for stochastic net (left) and non-stochastic net (right).

Right side of Figure 4 shows the editing capabilities of the transition when the option for stochastic net is turn off. In this case, it is possible to set the selected transition as deterministic or stochastic (in the case that it is not desirable that all transitions are stochastic). A sample of the setting with the deterministic delay illustrates Figure 5.

Editing options for oriented edges are displayed in Figure 5. Each edge allows to edit the input object (a place or transition) and the output object. For edges, it is possible to edit its name, multiplicity, use of Bezier curves, use of smooth Bezier curves (Bezier curves with auto-complete function, see Figure 6), ability to set the edge as an inhibitor, size of the arrow and the colour. Each edge consists of an arbitrary number of points by which it bends (or that specify parameters for the design of Bezier curves). New points are added by a user clicking the left mouse button on the grey square, which is located on the edge or near edge if using the Bezier curve, see Figure 5. By clicking the grey square it changes colour to red. The user can delete any point by double clicking the point with left mouse button. Other operations with points are the dragging (same as objects) and selecting (same as objects). The selected edge changes its colour to red.

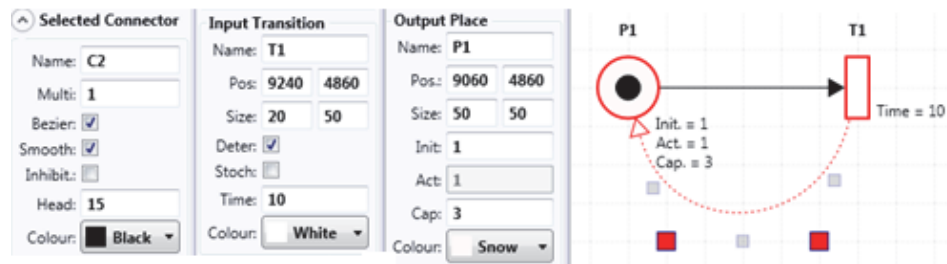


Figure 5 – Editing options for oriented edges.

The use of smooth Bezier curves is influenced by the behaviour of the individual points of the curve (oriented edge) while the user drags some point. Each cubic Bezier curve contains the starting point, 2 middle points and the final point. When a user adds more than four points, new Bezier curves are created according to the rule: the final point of the previous curve is the starting point of the current curve. To make sure that the transition between each curve is smooth, it is necessary that the second middle point of the previous curve is the mirror image of the first middle point of the current curve (with the starting point of the current curve in the middle). This relationship shows Figure 6, where there are 3 Bezier curves, i.e. there are 2 “mirroring” relationship, which are illustrated by straight lines.

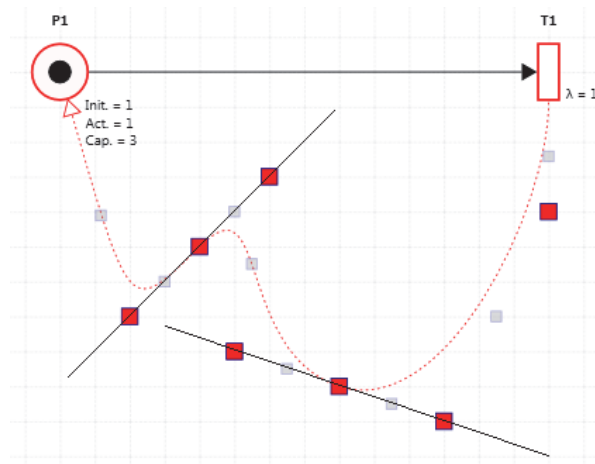


Figure 6 – Smooth Bezier curves.

If the edge is set as an inhibitor, the visual representation of its end changes from an equilateral triangle to a circle, see Figure 7. The edge of type inhibitor does not transmit any tokens and is used for check if the token in the input place/places is present. If the input place does not contain any token, the transition can be executed. The inhibitor edge can only be defined between the input place/places and the output transition and is used primarily to simplify the model. Thus, it ensures a better readability and clarity of the model and in addition, a more efficient implementation of the analysis (more compact size of the reachability space). In some cases (non-binary systems) it is not possible to model without use of this type of edge, for instance, the systems that use the buffer (to test whether the buffer is empty, etc.) (Murata, 1989).

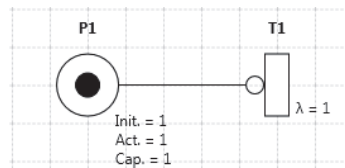


Figure 7 – Visual representation of the inhibitor edge.

Figure 8 illustrates the last two options associated with the editing of objects is setting default values (if nothing is selected, i.e. the user clicks on the background) for individual objects, and bulk editing of selected objects (if the user selects more than one object). It is possible to significantly relieve modelling effort when working with more advanced systems for which it is necessary to visually distinguish the different types of nodes or a specific subnet.

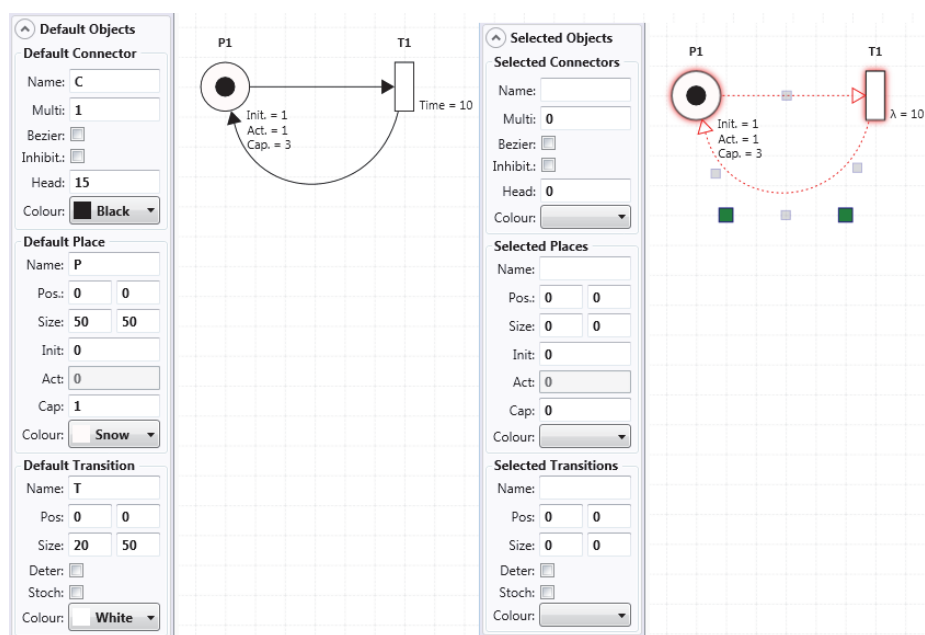


Figure 8 - (a) Editing of default values (b) Editing of selected objects (multiselection)

## A visual representation of the dynamic behaviour

The editor allows to perform a simulation of the network dynamic behaviour, which is based on the structure and the initial marking of the network (or capacities if enabled). Overview of simulation options illustrates Figure 9.

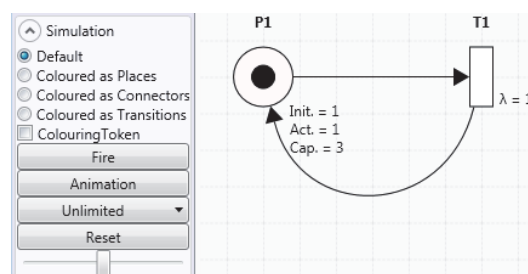


Figure 9 – Simulation options of dynamic behaviour.

The individual setting options are the following:

- The colour of the token (default “LimeGreen”), which can be changed so that the token colour will be the same as 1) the place it is connected to 2) the transition it is connected to, or 3) the edge it goes through.
- The option to turn on/off the colouring token, i.e. for the binary nets, if this option is turn on, then token does not appear as a black circle, but its presence activates the colour of the place (if the place does not contain any token, its colour is set to “Transparent”).
- The “fire” button that allows to run a single step of simulation/animation, i.e. testing all transitions whether it is possible to execute them (to transfer tokens from all input places to all output places). The number of transitions that are executed, can be explicitly restricted by selecting the limit for the number of transitions carried out in one step. The limit can be set between 1 and 10 transitions or unlimited (default option).
- The option to run an animation. The same as the previous option (“Fire”), but in an endless cycle.
- The option to change the speed of the animation (slider). The interval of the slider is  $x \in \langle 1, 12 \rangle$  and the time of animation in microseconds is calculated according to the rule  $\text{Time} = 5e^{0.69315x}$ . This rule ensures that the change of speed is smooth. The duration of the animation depends on the position of the slider from 10 milliseconds to 20 seconds. Part of the whole process of animation is the wait time before the next step (for visual readability of the marking). The period of waiting is established as one-tenth the time of animation.
- The option to reset the network, i.e. the current number of tokens is set to its default (initial) value for all places.

In addition, each animation token carries the number, which represents the multiplicity of the edge over which it is moved, see Figure 10.

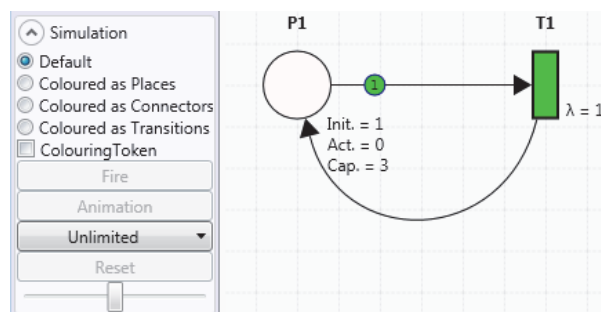


Figure 10 – Animation – Token is transmitted from the place P1 to transition T1.

When the option for the visual representation of a multiplicity is turned on, the size of the token is additionally increased by the size of the token value. Figure 11 illustrates the progress of the animation when the option for the visual representation of multiplicity is turn off (left) and on (right). The thickness is dynamically calculated for a given interval (maximum thickness of edges is 15 pixels.), which ensure a relative clarity and readability of the model.

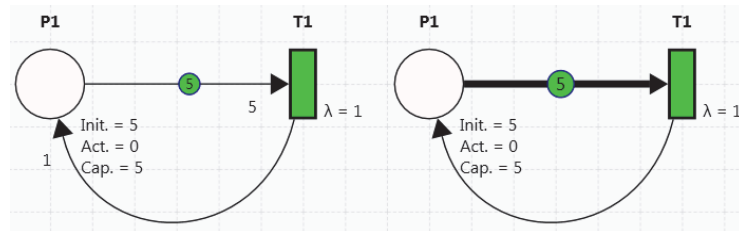


Figure 11 – The influence of the visual representation of the edge multiplicity on its thickness and the size of the token (right).

Outside of the visual representation of the dynamic behaviour, the simulation can be used for an approximation of the specific properties of the net (in the cases where it is not possible to use analytical solution).

### Comparison of selected applications in terms of user friendliness

Table 1 compares selected tools for modelling and analysis of Petri nets with the newly implemented editor.

Table 1: Comparison of user-friendliness features.

	New editor	HPSim	Woped	CPN Tools
Visual simulation (animation)	Yes	Yes	No	No
Mouse/keyboard shortcut	Yes	No	No	Partly
Bezier curves	Yes	No	No	No
Multithreading	Yes	No	No	No
Zooming	Yes	Partly	Partly	No
Panning	Yes	Partly	No	Yes
Colouring	Yes	No	No	Yes

## DISCUSSION

The issue of user-friendliness is important when choosing the appropriate tools for work or study. User-friendly tools are characterized by simple and consistent interface that contains visually uncluttered and strategically deployed elements of the user interface. Control of such a tool should provide users with a fast initial adoption of all structural and functional elements of the user environment and allow for the easier and faster (more effective) work overall. This is doubly true for education, since the complexity of the tool should not increase the complexity of the subject/course completion. In the framework of this work is discussed the user-friendliness of tools specialized for working with discrete event dynamic systems, namely Petri nets. Most of the freely available tools for modelling and analysis of Petri nets are exclusively developed due to the implementation of some new functionality, which is important especially in terms of science and research. One of the few tools, which allows to animate the dynamics of the network is HPSim (Anschuetz, 2003), which, however, does not allow any of the more complicated verification outputs (e.g. liveness). On the contrary, the tools that allow more complex verification outputs, do not support animation. For this reason, a new tool for the modelling and analysis of Petri nets was implemented, which development deals primarily with user-friendliness. This tool is planned to be used for the support of teaching of subjects such as Operating systems,

Systems Theory, Modelling of business process and more. The basic advantages of the newly implemented tools in terms of user friendliness can be summarised as follows:

- Visual representation of the simulation dynamics, i.e. animation, which speed can be adapted to the needs of users (from 10 milliseconds to 20 seconds for each simulation step).
- Visual customisation of the model and its elements. In particular, for instance, the ability to zoom, snap to grid (grid size can also be set), the colour and the size of the user's workspace, for objects it is possible to set their size or colour, for oriented edges it is possible to use Bezier curves or set their colour or thickness, etc.
- Additional feature such as unified position of the controls, the ability to work with multiple networks at once or the creation of new model objects by using keyboard shortcuts.

Another advantage of the implementation of the custom tool is the ability to incorporate new findings in science and research into one comprehensive tool that is able to further develop in the future. An example use of this tool as a support for science and research is, for instance (Ibl and Čapek, 2016).

## CONCLUSION

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In the context of this work is described the newly implemented tool that has been developed for the purpose of high user-friendliness. User-friendly tool is suitable to use, for instance, for the purposes of classical or distant education, as it allows students to quickly adapt the tool and moreover does not place too high demands on the work with the tool. Additionally, the tool can be used for the future implementation of new knowledge from the fields such as complex systems (e.g. the calculation of the model complexity) or information theory (e.g. the calculation of the model entropy) and many more.

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# Concept of Supporting university Education by using Students' Personal devices

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## Abstract

*Thirty years ago, Internet was not widespread, twenty years ago, mobile phones were not available for everyone, ten years ago, smart devices were not present in our households. Today the situation is quite different. Nowadays students grow up surrounded by these devices, they are accustomed to them and they are fond of them. Their learning methods are quite different from the methods of the former generations. Therefore, the modernization of university teaching methods is inescapable. According to our surveys taken during the autumn of 2015, more than 95 % of university students have personal smart phone, tablet or laptop. The same survey measured that students use their mobiles for educational purposes as well, follow the homepages of subjects, take photos of the blackboard, search for information on the net etc. Our concept states that universities should use these personal mobile devices to activate students, to help the educational process. For instance giving lectures for hundreds of students always entails the difficulty of finding out whether they understand it or not – and if not, what the common problem is. The authors implemented a prototype of a web-based system which offers the students the possibility to sign the professor immediately (using their mobile devices) if they do not understand something and conversely in which the teacher may ask questions like in a voting system.*

## Keywords

*Smart environments. Web application. Education. Modern teaching methods. Interactivity.*

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## INTRODUCTION

Decades ago, there was no other way to learn novelties than to go to the university and listen to lectures or to go to the library to search for information. Nowadays the

situation is quite different. Besides schools and traditional libraries, there is a big information source – the Internet, with a huge amount of always-available data information, documentation, etc. Of course, besides traditional tutorials, there is the possibility to take special course tutorials, e.g. MOOCs (*Massive Open Online Courses*), which are all very popular forms. Meanwhile, the learning methods and their expectations have also changed due to the modern possibilities. (Hayles, K., 2007)

David Willetts (ex-minister, UK) said that: “the area of old-fashioned university lectures – with students sitting in rows listening to academics – may be over as research shows large numbers of undergraduates now access professors' notes online... universities will have to radically modernise lectures” (Paton, 2014).

The authors of this paper are engaged to activate students to take part in the learning process operatively, strongly binding their attention. Therefore, it is evident that the traditional teaching methods have to be modified by using new techniques to motivate them. In a small learning group, teachers may use several teaching methods to make the lessons more interesting, more interactive, but with hundreds of students attending a lecture, it is not so easy. Simply, it is a fact that one rarely finds such a talented lecturer who is able to attract the audience's attention like a magnet. In case of virtual classes, where there might be several dozens of students, there are technical ways to share information, to work together, to be able to discuss the current ideas, e.g. different collaborative tools, such as mobile phones. (Wang et al., 2005) The authors of this paper have decided to use these technologies and methods in traditional lessons as well.

It is well known that there are existing voting systems available used by some universities for several years (University Cambridge, n.d. and Minnesota, n.d.), but those are rather expensive ones. Moreover, using a voting system means only one-way interactivity initiated by the teacher, who may ask questions and the students may choose from the given possibilities. However, what happens if they are having trouble with understanding something or they have totally lost the thread? They may indicate it by raising their hands in an old-fashioned way and they may ask the question, or they keep silent not to interrupt the lecture. The Enneagram spectrum shows the personality types of people describing nine personality types; there are ones who always want to avoid conflicts. What happens if the students send an anonymous electronic message to the teacher immediately with short information about having difficulties with the material? During the lecture, the professor can notice the message and may either decide to react immediately or continues the lecture undisturbed. Mixed with a voting system it would be a bidirectional interactive educational possibility.

Therefore, the aim is clear, but how could it be achieved? In a Faculty of Informatics, some facilities are already given like web-servers and Wi-Fi systems, but what can be used as client units? Anybody working in education may observe that many students have smart phones, tablets or a laptop, but the question is how many students exactly use them in the learning process. Therefore, the authors of this paper have prepared a survey in the academic year 2015-16, during the autumn semester, which measured the rate of smart device penetration among the students. The results have proven that the preconditions are ready to implement some ideas for using students' personal mobile devices. A simple prototype system is already available at the time of writing this paper, but it stands before testing it under real circumstances.

According to our hypothesis, this new type feedback method increases the efficiency of university lectures. In a multi-threaded information world, a one-way information system is not so efficient, thus, people need new techniques to transform it (from the teacher to the students) into a bidirectional one.

## PROBLEMS OF TRADITIONAL EDUCATION

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Among others, there are three general problems in today's traditional education.

- The youth are surrounded by different electronic equipment from which they get a great variety of existing, colourful media-information flood. They often sit in front of computers, their mobile phones are always near to them and the TV is turned on in the background. They learn soon how to pay attention to several things at the same time and to change from one to the other quickly – it is called hyper-attention. Thus, they are not accustomed to pay attention to only one thing like a traditional lecture which is a mono information-flood for them. (Dani E., 2013) A simple metaphor may be given from the world of operating systems: in a multi-process environment with only one processor (the students' brain), the scheduler must make a decision which process should be executed next. Usually it depends on the priority of the processes (and the priority of their mobile devices is rather high). Thus, a normal process (to pay attention to the learning) does not get enough resources – and that is just what the term starvation means. Therefore, they often loose the thread and they are not able to follow and enjoy a traditional lecture anymore. This monotony must be changed in order to achieve success in teaching.
- The efficiency of learning is in close connection with activity. Already Edgar Dale (1900-1985), an American educator dealt with it and developed the Cone of Experiences that shows the efficiency of different kind of learning methods. The cone shows that the best learning outcomes are provided by activity. (Figure 1)

That is why nowadays e.g. Inquiry-Based Learning, Problem-Based learning or Project-Based Learning is preferable. During a traditional lecture, the students see the presentation and listen to the explanations. They can usually download the learning materials so they do not even need to write them at all! Thus, some activity, some interaction must be taken into the lecture rooms.

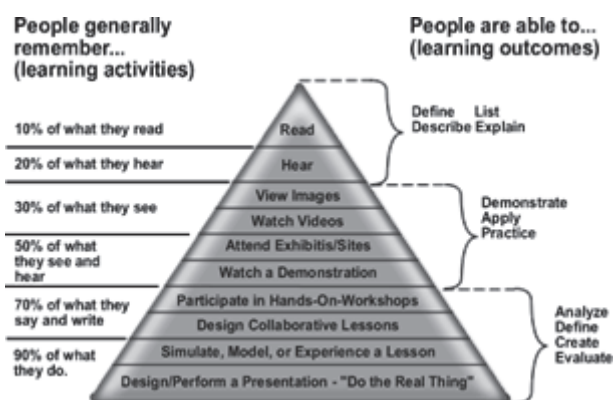


Figure 1: Cone of Experiences (Eduscapes, n.d.).

- Financial problems have to be mentioned too. Due to the survey – which asked more than 3000 university students in 2012 in Hungary – 35 % of the full-time students have to work during their school years. They stated that the greatest difficulty is to conciliate the school and the work. (Ládonyi, 2013) Some of them are interested in only those topics, which they can use immediately in their workplaces so they are not too motivated to learn other things. A bidirectional voting system may offer the possibility for the students with immediate feedbacks to modify the content of the lecture slightly fitting better to their needs.

## **SURVEY ABOUT PERSONAL MOBILE DEVICES AMONG UNIVERSITY STUDENTS**

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Therefore, the aim is given as the authors of this paper are determined to activate students and motivate them involving them better into the teaching process. What kind of tools does a Central European university have? Frankly not too much from one point of view. Usually there are not expensive ready-made voting systems and either do not have a budget for presenting each student a laptop who are attending these universities, but generally there are web-servers, free Wi-Fi system, knowledge to implement web and mobile software, motivation and the fact that most of their students have mobile phones, tablets or laptops.

The authors of this paper decided to work out a concept how to use mobile devices in education and how to teach development for mobile platforms, and gained a bilateral (Hungarian – Slovakian) two year long project Tet\_12\_SK (from 2015 – till 2016) to implement the authors' ideas (Illés, Z. et al., 2015).

Within the project, an online survey was constructed. The main question was how the university students use their personal mobile devices. The survey was not too long not to bore students in order to receive relevant answers. The survey was filled out by 610 students (310 Hungarian and 300 Slovakian). There were two main groups of questions:

- About their devices, operating systems and internet access
- About their mobile phone usage in education, social communication networks, taking photos of blackboards, recording videos of lectures, writing notes etc.

### **First group of questions**

The first group of question shows the students' ability to access data by mobile devices. The survey results showed that 95 % of students have adequate mobile phones for accessing data via Internet, but a lot of them have other type of devices such as tablets too. It is shown in Table 1 and Table 2.

Table 1: Personal mobile phones owned by the students due to the survey.

	Total	Hungarian	Slovakian
Smart phone	95,4 %	92,4 %	98,7 %
Conventional phone	3,9 %	6,3 %	1,3 %
No phone	0,7 %	1,3 %	0,0 %

Table 2: Data about other type of mobile devices owned by students

Total	Hungarian	Slovakian
65,7 %	62,3 %	69,3 %

At this moment, due to the above-mentioned data mainly smart phones are used in both countries for educational purposes. Thus, it is also interesting, which operating systems they use. In Table 3, the reader may observe the rates of different type of operating systems running on students' phones.

Table 3: Detailed data about mobile phones due to the survey

	Total	Hungarian	Slovakian
Android	69,8 %	68,4 %	71,4 %
Apple iPhone	3,3 %	0,3 %	6,2 %
Windows Phone	5,2 %	8,3 %	2,3 %
Other type	17,0 %	15,3 %	18,8 %
Conventional	3,9 %	6,3 %	1,3 %
No phone	0,7 %	1,3 %	0,0 %

The fact is that the result is not as good as it seems to be at the first glance at Table 1 and Table 2, because at about 21% of them do not use internet possibilities though they might use. The reason of it might be its charge. This is shown in Table 4.

Table 4: Internet usage due to the survey

	Total	Hungarian	Slovakian
Does not use internet	21,0 %	23,1 %	19,0 %
Uses internet	79,0 %	76,9 %	81,0 %

Another important question is related to the type of their internet access whether it is limited or not. Table 5 shows these results.

Table 5: Type of internet access usage due to the survey

	Total	Hungarian	Slovakian
3G/4G With limitation	63,7 %	75,2 %	53,2 %
3G/4G Without limitation	36,3 %	24,8 %	46,8 %

The above given results show that almost every student has a mobile phone. More than about 95 % of the students have smart phones, but at about 23 % of them do not have or do not use internet access. Among the internet users, there are 63 % having limitations in data amount.

These results have proven that today it is too early to use personal devices for obligatory tasks like organizing examinations through them however, they can be used for other purposes.

## The second group of questions

The answers for this group of questions help to review the habits how the students use their phones for studying purposes a university. The data of Table 6 shows that besides using social networks (Twitter, Facebook) for communication (90 % of students), many of them regularly use the web pages of the subjects (65 %). On the third place, there is taking photos from the blackboard with 49 %. It is a noticeable result because it means that almost half of them do not make handwriting notes for themselves. According to the Cone of Experience (Figure 1.) writing down something helps remembering the learning content! The results also warn the teachers to use newer tools besides the old ones to deepen the learning process.

Table 6: Type of mobile usage due to the survey

	Total
Social networking	90 %
Subjects' web-pages	65 %
Taking photos of the blackboard	49 %
Studying presentations	32 %
Studying online learning materials	30 %
Write notes	18 %
Using voting	8 %
Recording sounds	5 %
Recording videos of lectures	3 %

The survey also asked the students' opinion on which kind of application would they like to use in the campus through their mobile devices. They had a free textbox to write their proposals, where they mentioned some, but not too many as it follows in Table 7, where the data are not given by rate but by numbers due to the very small amount of answers.

Table 7: Students' suggestions

Suggestions	Number
Academic Information System	7
Notes	7
Translator/dictionary	12
Calendar for examinations, and other duties	6
M_Books for learning	1
Calculator	3
Language lessons, like duolingo	4
Skype, Twitter, Facebook used by the courses	1
Cloud data storage	4
Video course materials	1
Test/practicing	4
Campus map	8
Scheduler	10

Some of the suggestions are very interesting as for example the scheduler and the map of the campus application are ready and available in the AppStores.

## **ELECTION, THE PROTOTYPE OF A BIDIRECTIONAL VOTING SYSTEM**

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The idea of modernizing university lectures has led the authors of this paper to plan and implement some bidirectional communicating systems between the students and the professor during the lectures. The main aim is to activate students, to underline if there is something special in the topic, to observe the problems in real-time and to be able to follow their knowledge to fit the individuals.

### **Measuring students' knowledge and opinion**

During a lecture, there are several situations, in which professors would like to measure the knowledge level of their students. For example, in case of a part time training when students meet the lecturers only once per month, it could be interesting for the lecturer, whether students understand the basic ideas for the next module and if they will be able to do their next task at home.

- Measuring students' basic knowledge of a given topic in an auditorium with several hundreds of students is not that easy task to perform quickly without wasting too much time.
- To realize whether they understand a difficult theory, because without it, it is useless to proceed without explanations.
- Asking students for immediate feedbacks after the lecture about their opinions on how useful the lecture was and what their interest index is.

The above mentioned task might be executed by a traditional voting system. There is a great variety of it in the market. Some of them have free of charge versions too, but these versions have some limitations in usage – mainly in the field of accessing the formerly collected data, so it is not really suitable for university usage, where it could be important to compare data from several years.

The first, simple version of the system is ready. At the time of writing this paper, a lecturer may ask questions with several possible answers, and he may start the voting process and then later may stop it. Students receiving an URL from the teacher may vote with their mobile devices, laptops or tablets checking one of the given answers.

The following steps will be to add new features to the application, e.g. to be able to download the questions into the students devices with the correct answers etc.

### **Immediate signing or questioning**

From the other side there are situations where a student wants to ask something. Conversation started by a student is more interesting. During a lecture, students may loose the thread in situations when the professor is not expecting it. Sometimes they do not want to interrupt the lecture thinking that everybody else understands it. In this moment, the students may choose between two solutions:

- They may send a simple sign to the teacher without disturbing others or the lecturer during explanation. The sign arrives to the lecturer's device and the



application shows how many students have difficulties with this topic. The professor may decide either to stop and explain it again or to go further.

- Students may send actual questions as well if they can describe their problems. The professor sees the questions and determines the problem. He may decide whether to stop and answer the questions immediately or to postpone it.

This system also has an authorizing feature as well, which includes the personality check of the users, who must be the student of the subject. Students get an entry code from the lecturer, which is checked by the system as well. Besides it also makes an IP filtering, whether they are on the spot or not in order to avoid being disturbed by outsiders as it is shown in Figure 2.

The figure displays three panels of the 'eLecture for students' interface. The first panel shows a login form with fields for 'User name:' (containing 'Student'), 'Password:' (masked with dots), and 'Code:' (containing 'QwE'), along with a 'Submit' button. The second panel shows a 'HELP!' button and a 'Question:' field with the text 'What is the difference between...'. The third panel shows a 'Question:' field with the text 'Which operating system handles priorities in process scheduling?' and a list of checkboxes: 'Windows', 'Linux' (checked), 'Neither of them', and 'Each of them'. Below the checkboxes is a 'Send the answer' button.

Figure 2. eLecture surface for students: login, question sending, answering

From the teachers point they have to start the eLecture system at the beginning of the lecture by creating the login code and some files to start with as it is shown in Figure 3.

The figure displays three panels of the 'eLecture for teachers' interface. The first panel shows a message: 'eLecture system will help you to follow the lectures.' followed by instructions on how to use the system. The second panel shows a login form with fields for 'User name:' (containing 'Teacher') and 'Password:' (masked with dots), along with a 'Submit' button. The third panel shows a 'Start eLecture process' button, a 'Stop eLecture process' button, an 'Actual code:' field (containing 'QSEK57'), a 'New code' button, a 'Delete helps' button, and a 'Delete Questions' button.

Figure 3. Teacher's surface of eLecture: home, login, start to work

After this, the system accepts questions from the students and the teacher may observe it through his device and may decide in real-time what to do with them or uses the voting system to put questions to the students.

The whole process is logged; therefore, the system can also be used as some kind of catalogue system, if it is needed. Lecturers may follow who is active in questioning, who

has problems and what kind of difficulties in order to be able to help in a personalized way.

## **SUMMARIZING THE FIELDS WHERE MOBILE DEVICES MAY BE USED IN EDUCATION**

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New technologies find their way in education following the Gartner-Hype graph. (Gartner-Hype, n.d.) In this case, mobile devices are in the focus (Illés, Z. and H. Bakonyi, V., 2015). One way to group the usage of mobile devices and applications by their content is similar to the following description (Kismihók, G., 2008):

- Managing university life
  - Mobile applications for general campus information.
  - Mobile optimized web pages for the subject.
  - Accessing the schedule using mobile devices.
- Offering direct help for courses
  - Usage of social networks to strengthen communication between students and teachers.
  - Voting systems to offer possibilities for immediate questioning of the audience (H. Bakonyi, V. and Illés, Z., 2014)
  - Note making possibilities for downloaded presentations using mobile applications, etc.
- M-learning materials (mobile-learning)
  - Short contents only to give additional help in learning like listing notions, definitions, questions and answers.
  - Full m-learning materials for whole courses or only for parts of them.

The possibility to develop different type of mobile assistance for university education is the interest of the authors for several years (Illés, Z., Pšenáková, I. and H. Bakonyi, V. 2008). From the groups listed above, the authors have already implemented some, like mobile-optimized web pages or a mobile schedule application written by the Mobile Academy (Menyhárt, L., Illés, Z. and H. Bakonyi, V., 2014). In this paper, the bidirectional voting system was presented for the reader. There are many further plans like creating online catalogues, searchable presentations by notions, etc. Therefore, the work has been started, but there is still a lot to do.

## **CONCLUSION**

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The first decades of the 21st century according to increasing penetration of the mobile devices have caused a real revolution in education too, using new mobile technologies and relevant methods. The usage of mobile devices in educational processes is not a very new idea, the usage of personal mobile phones in distance learning had also been published before. According to the survey almost every student has an adequate smart device (notebook, smart phone, tablet). The new idea now is to create a new concept, how these devices can be used in education. The usage of smart phones and

other mobile devices to modernize education will need something new. The bidirectional interactivity, supported by eLecture system, will prove the efficiency of traditional lectures.

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# The Virtual Laboratory Work “Measurement of the Horizontal Component of the Earth Magnetic Induction”

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## Abstract

*Nowadays, in the age of information technology, the ways of teaching and learning are changing significantly in schools and especially in universities. Lecturers cannot teach as they did 10 or even 5 years ago. New training tools based on information technologies emerge. And in order to provide education quality of high modern standards, teachers need to introduce new teaching techniques and tools with use of information technologies. One of these new approaches is applying virtual laboratories, which are able to replace real ones in many cases. In this paper, the advantages of virtual laboratories are outlined. The authors present the virtual laboratory work on physics “Measurement of the horizontal component of the Earth magnetic induction”. The physical principle of the experiment is described. The technological basis, the structure and the development of the laboratory work are given. The ways of interaction between a user and the virtual lab are shown.*

## Keywords

*Virtual physical laboratory. Higher education. 3D modeling. Microsoft .NET XNA. C#.*

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## INTRODUCTION

At the present time we can witness the rapid development of information technology, and how it affect and change all fields of our life. Education in general and higher education in particular are not an exception. Introduction new information technologies, along with computerization of educational institutions and innovative activities of faculty staff are the main directions of modernization of education, to which a special attention is paid not only in Kazakhstan, but all around the world (Cheremisina, et al., 2012; Kudinov, 2009; Daineko and Dmitriyev, 2014).

Using innovative teaching techniques and new ways of interaction between teachers and students lead to renovation of educational process as well. In this context, using computer-based training systems is highly interesting. According to Brusilovskiy (1992), they facilitate mastering new material, help to track the level of performance and prepare

new teaching material. Among them are automated tutorials, library systems, multimedia training systems or simulators and others.

Virtual laboratories gain more interest as a new learning tool (Daineko, et al., 2015a).

Based on the functionality provided virtual laboratories can be divided into the following groups (Yefimov and Nikolayev, 2008):

- demonstrations, which are not computer laboratories in the full sense, since they only demonstrate experiments without interactivity;
- simple models are separate laboratory works, combined into a full laboratory based on some feature. Usually such laboratories are easy to implement, since they consider one simple process, which can be described with one or two mathematical formulas;
- universal laboratories for a particular group of phenomena are complicated modeling systems with complex mathematical apparatus;
- universal laboratories can combine several phenomena of different nature in one experiment;
- simulation laboratories allows conducting experiments, which cannot be performed in real life due to the high implementation cost or because it is impossible to create necessary conditions.

Compared to traditional laboratories, virtual ones have a number of advantages (Trukhin, 2002).

First, virtual laboratories do not require acquisition of expensive equipment or dangerous radioactive materials. Nevertheless, at the same time, they allow studying such complicated phenomena as Zeeman and Stark effects, nuclear reactors, determination of the crystal lattice by electron diffraction and others.

Second, in virtual laboratories with help of animated models it is possible to observe the dynamic illustrations of chemical or physical processes, which cannot be seen in real experiments. For example, using virtual laboratories students can get inside and, therefore, better understand such processes like motion of charged particles or principle of the p-n-junction and others.

Third, virtual laboratories allow studying processes, which last a split second or several years. For instance, studying planetary motion in the gravitational field of a central body becomes more convenient.

Another advantage of virtual laboratories is safety issue. Using them is completely justified in cases of labs with high voltage or dangerous chemicals.

One more advantage of virtual laboratories is that they allow conducting a series of experiments with different input values. In addition, usually they provide automated processing of input and output data. This is not always possible in a real lab.

Virtual laboratories are indispensable for distance learning, when students cannot work in the real university laboratories (Daineko, et al., 2015b).

However, virtual laboratories have a number of disadvantages as well. The main is that they do not provide a direct contact with an object of research, equipment or device. It is unacceptable to teach a student showing him a technical object only on a screen of a

monitor. Another disadvantage of virtual laboratories is that students do not get hands-on experience with laboratory equipment and practical skills in measurement of values. Moreover, in virtual laboratories equipment and devices are ideal without any errors, which is impossible in reality. In addition, to the disadvantages of the existed virtual laboratories, one can refer narrow specialization and in more cases the linearity of the experiment that is when the whole sequence of actions and results of the experiment are given in advance. In such a way, the optimal solution is to combine traditional laboratories with virtual ones, taking into consideration the pros and cons of both of them.

In this paper the authors present the virtual laboratory work "Measurement of horizontal component of the Earth magnetic induction", which is a part of the Physics Virtual Laboratory. The work is done in the Computer Engineering and Telecommunication Department of the International Information Technology University, Kazakhstan, Almaty.

## THE PHYSICAL PRINCIPLE OF THE EXPERIMENT

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The aim of the laboratory work "Measurement of the horizontal component of the Earth magnetic induction" is the determination of the horizontal component of the magnetic field of the Earth using a tangent-galvanometer. The tasks of the work are the study of the magnetic field concept, the characteristics of the magnetic field, the study of Ampere force, the Biot-Savart-Laplace-Ampere law and the superposition principle of the field. The tangent-galvanometer is a coil, in the center of which, on a vertical axis, a magnetic pointer is. The pointer can rotate freely inside a circular box with a transparent cover (compass). A circle scale graduated in degrees is on the contour of the box bottom.

In the absence of the electric current the pointer is oriented along the magnetic meridian ( $\vec{B}_0$ ) direction. The coil's plane is a set of the planes of magnetic meridians. After the electric current is switched on, the induced magnetic field is also acting on the pointer. The pointer is arranged along the resultant magnetic field  $\vec{B}$ , turning around by the angle  $\alpha$  (Figure 1). The induced magnetic field  $\vec{B}_I$  can be expressed as follows:

$$B_I = B_0 \operatorname{tg} \alpha \quad (1)$$

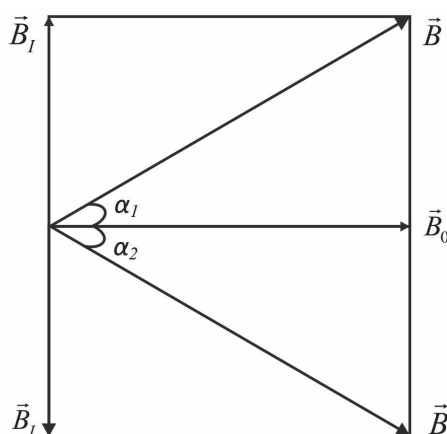


Figure 1: Vector diagram.

If the number of coils is  $N$ , then the induced magnetic induction is equal to:

$$B_I = \frac{\mu_0 IN}{2R} \quad (2)$$

where  $N$  is the number of coils;

$\mu_0 = 4\pi 10^{-7} \frac{H}{m}$  is a magnetic constant;

$R$  is a radius of the coil.

As a result, we gain the following engineer equation for the measurement of the horizontal component of the Earth magnetic induction:

$$B_0 = \frac{\mu_0 IN \operatorname{ctg} \alpha}{2R} \quad (3)$$

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## IMPLEMENTING THE VIRTUAL LABORATORY WORK

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### Technological basis

When choosing the software environment for development of the virtual physical laboratory the main criterion was the speed of creating projects. Virtual laboratory works have to replace real experimental installations. Therefore, their quantity can be unlimited, which is one of the main advantages of virtual laboratory works in general. When choosing a development platform the review of the existing solutions, such as XNA Framework, Unity 3D Engine, and Unreal Development Kit has been carried out.

Microsoft XNA (from English XNA's Not Acronymed) represents the tools compatible to the manageable runtime environment (.NET), developed by the Microsoft company, which is intended to facilitate the development and management of computer games. The main concept of XNA implies that developers do not need to rewrite "the repeating pattern code". In addition, XNA provides integration of the majority of game development tools in a single system.

The basis of the XNA Framework consists of .NET Compact Framework 2.0 to develop games for Windows (some of the implementations provide development for the Xbox 360). The framework comes with a set of libraries that are directly used to create interactive games with high graphics, supporting maximum code reuse on all target platforms, which allows developing for different platforms. The execution of the framework takes place on a modified version of the Common Language Runtime, which is optimized for game development, with the purpose of providing a manageable runtime environment. The environment is available for Windows XP, Windows Vista, Windows 7 and Xbox 360 (Winterhalter, 2011).

The toolkit includes:

- wrapper over DirectX (Direct3d, XINPUT, XACT);

- the classes Game, GameComponent, GameWindow, which are the framework for game applications;
- a set of auxiliary classes / structures for work with vectors, matrixes, beams, quaternions, and different mathematical functions (the functions, which are not implemented in standard System.Math are provided);
- Content Pipeline structure that determines the specific to XNA system content.

XNA platform has a strong emphasis on the Object-Oriented Programming (OOP) paradigm, which allows optimizing code, accelerating the development process and modifying code in teamwork (C# Language Specification, 2015).

### **The structure and implementation of the laboratory work**

The laboratory work as a game application on XNA consists of the following mainframes:

- content and its loading (resources for game graphics, texts, audio files, etc.);
- graphics display (2D in this laboratory work);
- control processing (game reaction to various events from the mouse, gamepad or keyboard);
- game logic and interaction of all game components.

As a core of the laboratory work, as well as a core of any game on XNA the Game class is used. In the Game class the abstract methods Draw, Update, LoadContent, UnloadContent, Initialize and others are implemented. Thereby, each subsequent application is inherited from this class and overrides the important methods (events of the Game instance) for its purposes. This determines the logic of the future application. Also, the properties of the parent Game class are GameWindow classes, GraphicDevice etc. (Winterhalter, 2011).

The implementation of the base class allows running the game loop, cleaning the screen (filling with a uniform color), and handling the events when pressing certain buttons (closing a game window). Loading the content is carried out in LoadContent method.

### **Loading the content**

Work on XNA assumes specific operations with the content of the system.

XNA provides a set of "content processors" and "content of importers" (in addition to the use of standard resources, it is possible to add our own).

The content of importers at the compilation stage will transform the content from the external supported format to the internal representation, compatible to XNA (Winterhalter, 2011).

Then, the program resources, such as textures in dds, bmp and png formats at the compilation time are converted into the single internal format, uniform for all structures. This approach allows avoiding the dependence on a content format, for example, when using md3 models, it is necessary only to write additional content importer.



The content processors are engaged in reformatting the content from internal representation to objects of the managed code, such as loading the content into the memory at the execution stage.

Moreover, XNA provides finished importers and processors for the main types of content.

As a rule, Solution Explorer studio is used to add the content to the application, into a special folder "Content". Here, a certain processor and importer are assigned for each resource.

The content of managed code is presented in the classes Texture, Texture2D, Model, Model Mesh, Effect, etc.

Loading in a code is made through the class ContentManager (Content Field Class Game), and is carried out in the method LoadContent of the Game class (according to the good programming style).

The standard processors support the following:

- models;
- textures;
- raster fonts;
- shaders.

## **Graphics display**

Graphics and text display is based on the SpriteBatch class. Consequently, the SpriteBatch instance is created, when Draw method is called:

- SpriteBatch.Begin () begins drawing;
- SpriteBatch.Draw () is called for drawing of each sprite (drawing of all texture or its fragments);
- SpriteBatch.End () finishes drawing process.

SpriteBatch.Draw () parameters – the position on the screen, where the texture is drawn, rotate, skew, scale. Also, SpriteBatch class performs a sorting by the Z coordinate (automatically). The resource of texture is transferred to the SpriteBatch.Draw() method as a reference to the class Texture2D, which is obtained by uploading the content to the application.

## **Control**

The project of virtual physical laboratory work "Measurement of the horizontal component of the Earth magnetic induction" includes classes, the structure of which and relations between them are given in Figure 2.

In addition to the project classes shown in the figure, there is a special set of classes with static methods, such as Keyboard, Mouse, GamePad, which represent a particular device. Each class has the GetState() method, which returns respectively KeyboardState, MouseState, GamePadState, such as X, Y position of the mouse cursor, or a state of the keyboard key.

The list of the project classes is as follows:

- Button;
- Desktop;
- DesktopElement;
- Element;
- Frame;
- Global;
- Message;
- Table;
- Toolbars;
- Toolbox;
- ToolboxElement;
- Wire.

Circuit Testing is performed in the class Button, in the checkCircuit() method. The program determines if the necessary elements are on the screen (the list of items defined in the array) and if they are connected (the connection is defined in the class Wire). Table is a class, which is responsible for displaying the table and information in it.

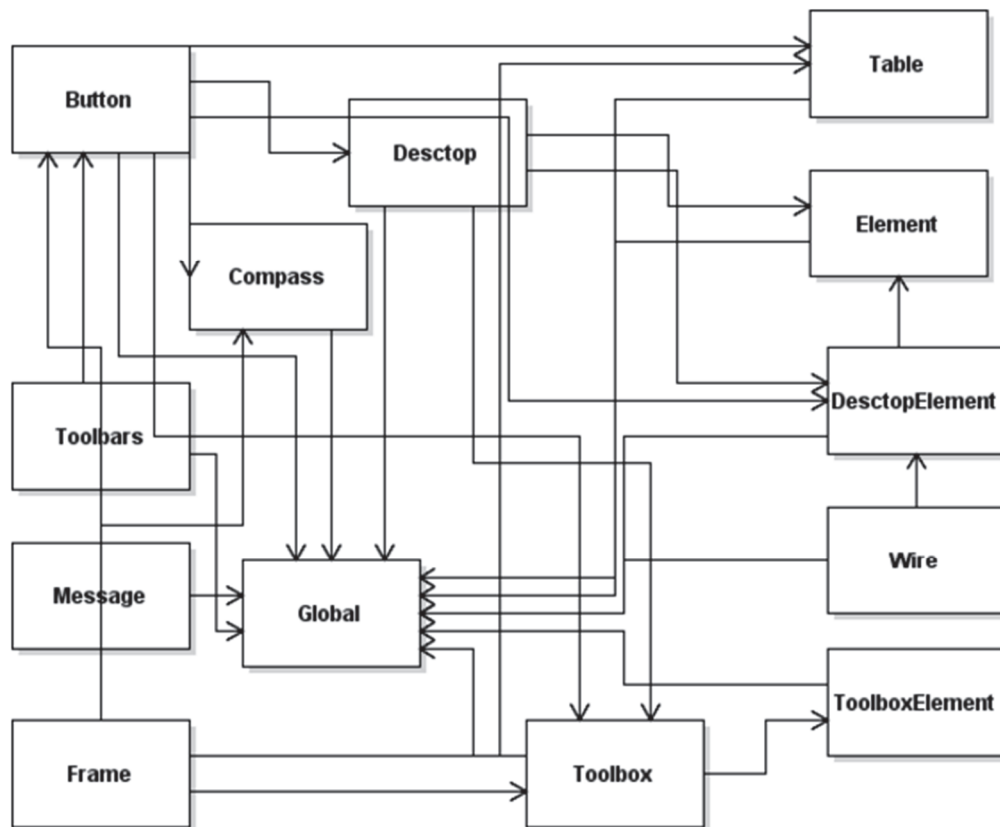


Figure 2: The class diagram of the virtual laboratory work "Measurement of the horizontal component of the Earth magnetic induction".

Running the game application on the user's machine.

The list of the software that is needed to run the laboratory work on the user's personal computer is as follows:

- .NET framework 2.0 Redistributable;
- XNA Redistributable;
- DirectX Redistributable.
- In addition, a video card that supports Shader 1.1 is necessary.

## User interaction

The process of conducting the virtual laboratory work is the realization of a certain sequence of actions, which includes input of initial data, start of an experiment and registration of the results. Figure 3 shows a flow chart of user interaction with the laboratory work "Measurement of the horizontal component of the Earth magnetic induction".

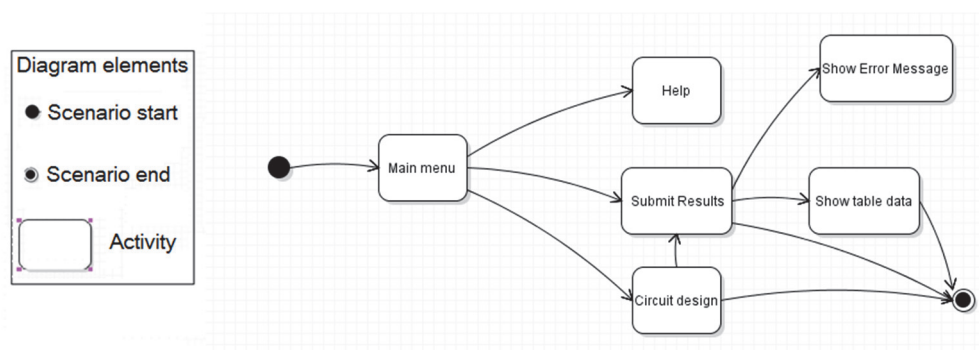


Figure 3: The state diagram of the virtual laboratory work "Measurement of the horizontal component of the Earth magnetic induction".

The beginning of the scenario signifies an entry point to the laboratory work. After the program is run, the main program menu is displayed to the user, which is designated as Desktop. In addition to the stand simulation for building an electric circuit, the main menu has the Submit button to start the simulation of circuit locking/disjunction and the Help sign. After the circuit is locked, the results of calculations and the readouts of the circuit elements are registered in the table (Table class). All the elements of the project are connected using a special Global class. In case of incorrectly built circuit a special error message ("Circuit is incorrect") is displayed.

Windows control elements were used for the design of the user interface for this virtual laboratory work. In general, all students are familiar with Microsoft Windows operating system very well. And the usage of usual control elements, such as buttons, input fields, windows, scrollbars, etc. simplifies the process of understanding and conducting the virtual lab. Moreover, the full reference is available to students. The interface model for the laboratory work "Measurement of the horizontal component of the Earth magnetic induction" is given in figure 4.

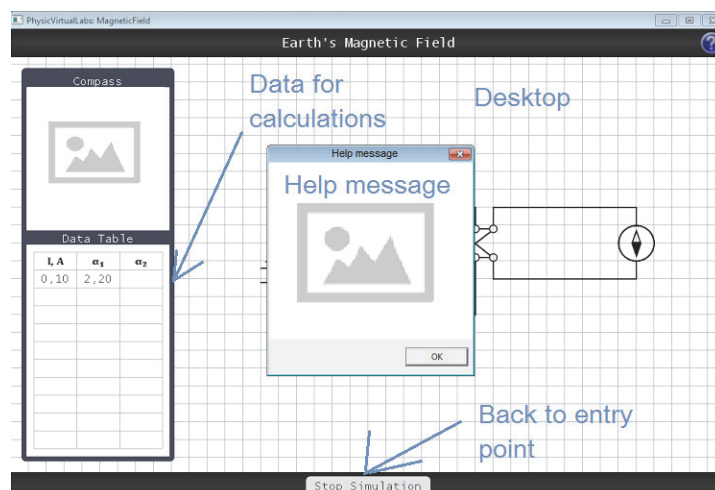


Figure 4: The model of the interface of the virtual laboratory work “Measurement of the horizontal component of the Earth magnetic induction” (Entry point).

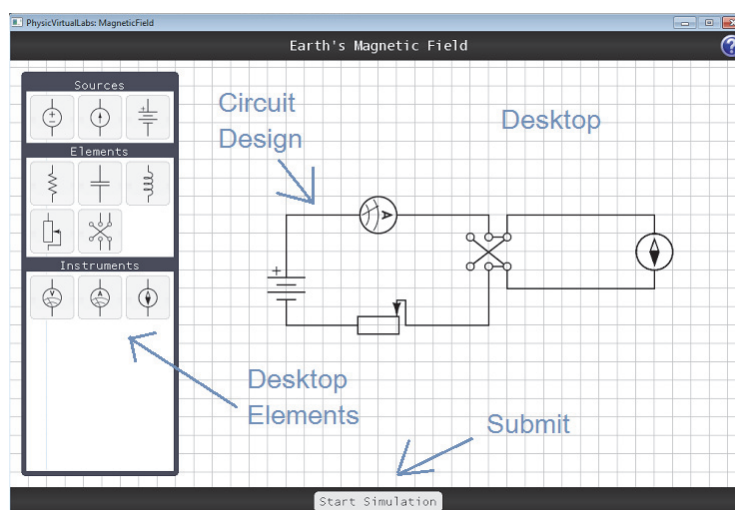


Figure 5: The model of the interface of the virtual laboratory work “Measurement of the horizontal component of the Earth magnetic induction” (Simulation).

Students are given a training simulation stand to build an electrical circuit (Figure 5). In this case, students choose items from the list of tools and place them on the stand. Students need to stretch a wire between the elements to build a circuit. The wire is a tool by default, therefore, if none of the tools is chosen, a working element is the wire. The buttons to begin the simulation and the auxiliary menu are located on the initial screen. If the circuit is built wrong, the error message is appeared. During the simulation, students have the option to stop the simulation and to continue building a circuit from the last saved state.

## CONCLUSION

Thus, modern information technologies allow conducting any forms of experimentations, open the broad prospects for the creation of original and sometimes radically new virtual experiments, not only in teaching physics. The way of the creation of

the virtual laboratory work "Measurement of the horizontal component of the Earth magnetic induction" based on Microsoft .NET XNA is shown in the article. The software lab model, interface and method of implementation of the laboratory work are described. We believe that the developed virtual physical laboratory for students of higher educational institutions of the natural sciences and technical specialties is a modern innovative embodiment of computerized learning systems of new generation.

## **ACKNOWLEDGEMENT**

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The project was accomplished with the financial support of the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan according to the Program of grant funding of scientific research in 2015, 2622/ГФ4, reg.№ 20150115PK01145.

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# Classroom Learning Activities Based on Real-time Response Processing

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## Abstract

*The classroom response systems (CRS) help teachers to improve their instructional methods towards more learning and less teaching strategies and so provide students with better opportunities to learn. In this paper, we present a pair of case studies from a graduate course on compilers taught to students of applied informatics. The first one was aimed at enhancing the constructivist and collaborative learning during lectures by posing questions focused on abstract concepts followed by class-wide discussion about the answers. The positive pedagogical effect of this method was confirmed as the students' level of understanding was increased rapidly. To pursue the formative assessment effectively, the Socrative CRS was used to collect and visualize answers being submitted by students through their smartphones. In the second case, the Socrative CRS was used in a computer laboratory in a more traditional way, to realize a short summative test. Though the learning outcomes were not influenced directly, the immediate feedback on students' knowledge was useful for revising the learning scenario. In both cases, teacher could diagnose the misconceptions easily. All students were challenged to think of solutions and discuss with others so their engagement was obvious. Most of them clearly appreciated the active learning environment supported by the interactive educational technology.*

## Keywords

*Classroom response systems. Socrative. Mobile computing devices. Formative assessment. Student engagement.*

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## INTRODUCTION

A classroom response system (CRS) is a set of hardware and software components designed to make the learning activities based on posing questions more effective. While teaching a large-scale group of students, it is difficult to get feedback from every single individual or make students stay focused and involved throughout the whole lecture. The idea to enhance the face-to-face questioning technologically is rather old, though many of the opportunities provided by the actual CRSs are new with strong potential to encourage the engagement of students significantly.

Nowadays, the CRS functionalities (Figure 1) are typically implemented with a wireless communication technology. Many older, but still popular solutions provide students with

dedicated handheld devices (often referred to as “clickers”) for transmitting answers to a teacher’s receiver unit via the infrared or radio signals. In contrary, modern systems profit from the existing computer network infrastructures, so students can use their smartphones, tablets or notebooks to participate. The latter approach (known also as the „bring your own device“ policy, BYOD) might be found more attractive and flexible as it generates no additional costs or demands on the faculty staff. In a state-of-the-art analysis (Haintz, Pischler and Ebner, 2014), the features of more existing web-based response systems were compared systematically.

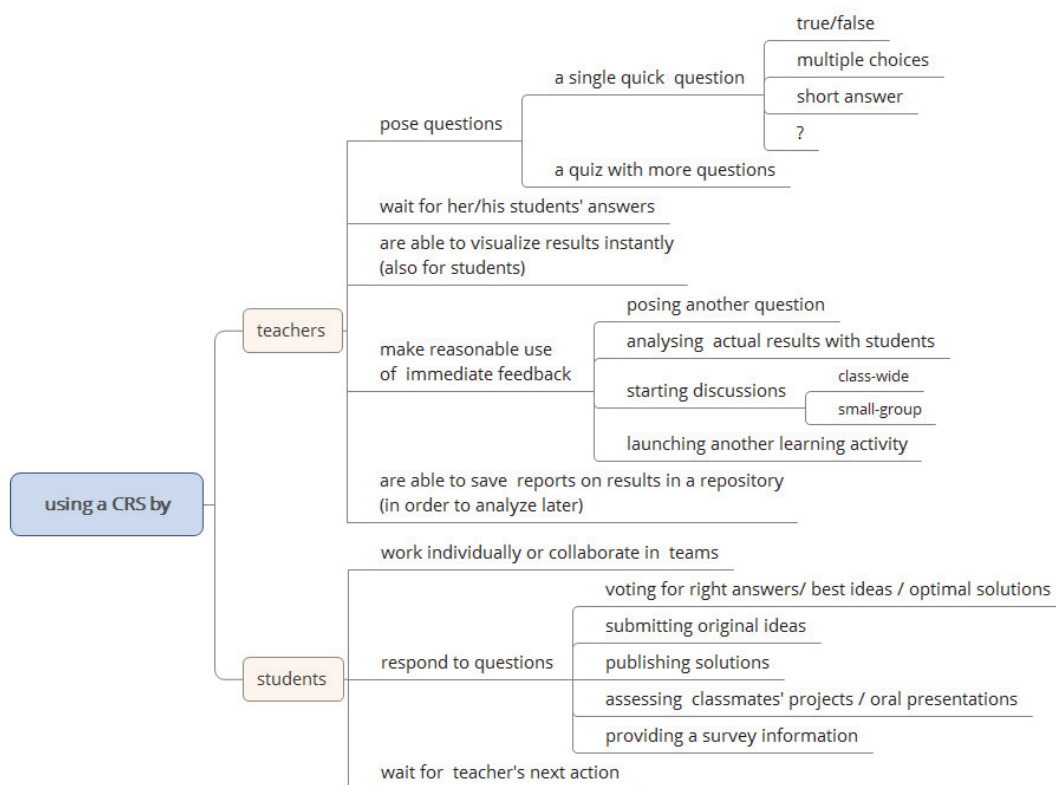


Figure 1: The overview of standard actions when applying a CRS teaching strategy

Benefits of CRSs may be discussed from a teacher’s as well as a learner’s point of view. In our research, we target two major problems related to the productive integration of the interactive educational technology, both within the context of various computer science courses:

- how to upgrade a student’s learning experience and overcome the issue of passive listening,
- how a specific CRS may assist teachers to pursue the formative assessment better and promote the immediate revision of teaching scenarios when needed.

During longer lectures, especially when the topic is too theoretical, abstract and complex, the „paradox of a demanding stuff“ can be noticed quite often: though teachers are trying hard and students are paying attention, there may be a very little learning going on actually. Students are likely to lose motivation soon after not having understood the first fundamental concepts and procedures. Formally, they follow their lecturer’s speech further, but having postponed their ambition to grasp the point for later. When only some

students communicate with teacher, information about the progress of the class is biased. After the lecture is over, those students who have not been challenged to participate actively may feel unsatisfied or even find the face-to-face session a complete waste of time.

For us, to upgrade a learning experience means to provide all students with better opportunities to learn. Drawing on the constructivist and constructionist learning theories (Ackermann, 2010), we suggest interleaving the traditional course of a lecture with several questions and hands on tasks that would enable students the immediate application of new knowledge, promote class-wide or small-group discussions and facilitate the collaborative learning. To manage such interactive teaching scenarios more effectively, a CRS can be a very useful tool (e.g. Méndez-Coca, Slisko, 2013; Liu, Taylor, 2013; Dervan, 2014; Awedh et al., 2014; Dakka, 2015). In (Bruff, 2009), the author also uses clickers in order to create an active learning environment in his classes and provides a valuable practical guide for instructors with lots of inspiring case studies from a wide range of disciplines, including e.g. mathematics and engineering. He always points out the pedagogical, not the technological aspects of the learning activities concluding that the impact of using CRSs on students' learning outcomes seems to depend in large measure on the instructional methods by which the technology is used. To support this idea, we suggested an original taxonomy of the learning activities that we find suitable for implementing with a CRS (Table 1).

Table 1: Learning activities driven by a CRS

Type of activity	Goals	Attributes	Benefits for learners	Examples of activities
test (quiz)	to automate student assessment	mostly asynchronous, student-paced and non-anonymous answers, not requiring any fundamental change of teaching strategies	increases the extrinsic motivation to learn, gives feedback on actual level of knowledge	summative or formative didactic tests, knowledge quizzes, competitions
quick question	to explore the level of student understanding and stimulate engagement	synchronous, anonymous or non-anonymous answers, projection of results with instant feedback through class-wide discussion, the instruction proceeds respecting the findings about the students' comprehension	encourages active thinking, reveals misconceptions, helps to identify the essential elements of the curriculum	real-time checkpoint questions followed by discussion on wrong and right answers
collecting ideas	to support collaborative learning	synchronous, anonymous, multiple answers with their projection and the instant feedback through class-wide discussion, crucial influence on the instruction progress,	fosters creativity, students can profit from the collective intelligence, share knowledge and experience while solving problems	generating creative ideas in brainstorming  sharing different answers/solutions to divergent questions/problems



		high degree of constructivism		
voting	to promote critical thinking	synchronous, anonymous answers, bar chart visualizes the summary of results, affects the course of instruction a little	provides chance to judge the quality of information and solutions	voting for best ideas, peer evaluation of projects or presentations
survey	to determine students' attitudes, opinions and interests	anonymous, asynchronous or synchronous answers, with or without the instant feedback from a teacher, with no influence on the teaching scenario	enables students to present opinions, subjective preferences or ask questions	ice-breaking questions contributing to positive communication atmosphere, back channel questions, self-evaluation surveys

The taxonomy derives from a series of case studies that we carried out over a period of two academic years. All experiments were realized using the Socrative CRS (Socrative.com, 2016) during classes taught to students of applied informatics or prospective secondary school teachers (formal languages and automata, computational complexity of algorithms, compilers, object-oriented programming, functional programming, and didactics of informatics).

In this paper, we present a pair of case studies from a graduate course on compilers in detail. Both case studies were aimed at developing and exploring the original interactive learning activities grounded in real-time response processing. First, the objectives together with some implementation issues of the conducted experiments are described. The results are analyzed later, in a separate section.

## METHODS

### Case study I

The first learning activity was designed to accomplish the *formative assessment during a lecture* more effectively. We assumed that the suggested intervention, though simple, would:

- transform the passive audience into engaged learners willing to think of the lecture's content seriously,
- make students to construct their knowledge actively through discussions and sharing ideas with classmates,
- provide lecturer with a relevant feedback about her students' actual level of comprehension.

Two types of questions (Q1 and Q2) were posed repeatedly over the course of the introductory lecture (20 students of applied informatics) on fundamental terms related to formal languages (e.g. alphabet, word, language, operations on languages etc.):

Q1: Form a word that belongs to the formal language L.

Q2: How many words are in L?

The questions were asked three times with different formal languages. The scenario proceeded as follows:

- posing a first type question,
- collecting answers,
- visualizing answers for students to discuss their correctness,
- posing a second type question,
- collecting answers,
- final discussion to sum up the language's attributes.

The Q1 questions were meant to determine students' initial understanding of formal concepts that were introduced by definitions. Students were tasked to give specific instances of an abstract concept (well-formed words). The application of analytic thinking was needed. After this collecting phase, their suggestions were visualized and the whole-class discussion was launched to exclude all incorrect strings. This process resulted into building a set of well-formed words as a good starting point for initializing the constructivist learning. The abstract concepts are likely to be constructed naturally when students have chance to consider many of the individual cases. The subsequent Q2 questions should verify this assumption by measuring the level of understanding again. We were interested, whether students would manage to identify an essential attribute of the abstract concept (number of elements belonging to the set).

Besides the process of collecting and visualizing of responses, the Socrative CRS enabled teacher to edit the list of words during the ongoing discussion interactively. Students used their personal smartphones to respond, they were free to participate and could collaborate in pairs or groups. The questioning was teacher paced and anonymous.

## Case study II

The second of the proposed learning activities was designed to accomplish the *summative assessment during an exercise* (two groups, 20 and 18 students of applied informatics). The intervention should

- promote students' causal thinking,
- foster competences to explain solutions clearly by using the proper terminology,
- help teacher to diagnose the misconceptions effectively.

In this case, students were involved in a short summative test at the beginning of the exercise that followed the lecture on deterministic syntactic analysis (top-down parsing) and the LL(1) grammars. This test consisted of 4 questions about the specific context-free grammars. A sequence of Q1 (true/false) and Q2 (short answer) questions was repeated twice:

Q1: Is the given grammar of type LL(1)?

Q2: Write arguments for your previous answer.

Students used desktops to submit their answers because the lessons took place in a computer laboratory. Students were obliged to participate, they responded individually providing also their names (the identity of participants was needed in order to evaluate

their actual knowledge). The summative testing was implemented using a Socrative quiz. It was student paced and asynchronous. The solutions were discussed aloud immediately after finishing the test. The Socrative CRS was used to visualize results on a projection screen.

## RESULTS

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In this section, data analysis and observations from both experiments are summarized. We point out the main findings as well.

### Case study I

In this case, the voting procedure was voluntary, 12 of 20 students responded using their smartphones. However, all students were engaged in process of creating answers. The effectiveness of the learning activity was evaluated by analyzing reports saved by the Socrative CRS. Figure 2 shows the successfulness when answering each pair of questions. It is obvious, that the initial understanding of a new concept was poor as only 11% of students answered correctly. The other students did not succeed, because they did not understand the formal definition of a language. This confirms our assumption about their passive approach when not being challenged to fulfill a task or think of a question explicitly. The ratio of correct answers to second question was much higher; up to 44% of students were able to infer one of the language's essential attributes (number of elements). This question was preceded by a discussion about the concrete examples of words provided by students themselves. The increasing trend in successfulness is noticeable for both types of questions (Figure 2).

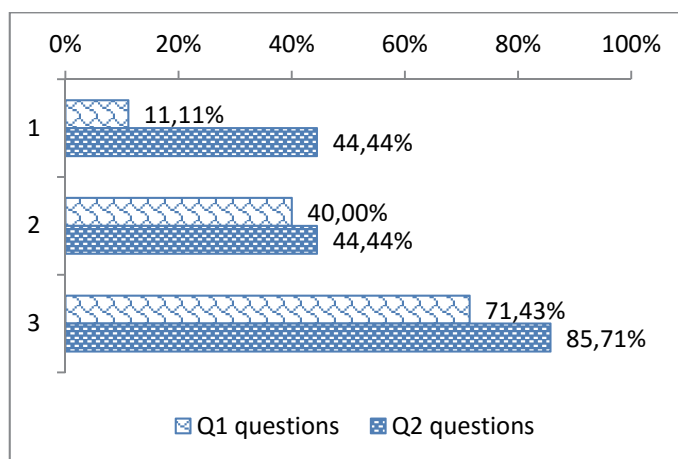


Figure 2: The correct answers for each round of questioning.

The idea of interleaving the lecture's course with interactive questioning showed up to be appreciated by students a lot. They liked having a chance to use their personal smartphones in a new way (while learning). Most of them clearly demonstrated that Socrative phases of the lecture affected the overall atmosphere very positively. From a teacher's point of view, the suggested learning activity was proved to be an effective intervention. The lecturer was able to notice potential problems in understanding immediately after the abstract concepts were presented to students. She stimulated a productive dialogue and made students to stay focused. By repeating the pairs of

analogical questions more times, the comprehension level was enhanced significantly. The collaborative nature of this learning activity contributed to the effectiveness as well. Sharing ideas in a group supported the process of gathering experiences and so led to better outcomes.

## Case study II

The results of a summative test are shown on a graph (Figure 3). In both of the two true/false questions (Q1), a high majority of answers was correct (68,42% and 73,68%). So we assumed that in most cases, students had not decided randomly. However, only 22,37% and 18,42% of students were able to provide proper arguments and explain their choice correctly when answering the next question (Q2).

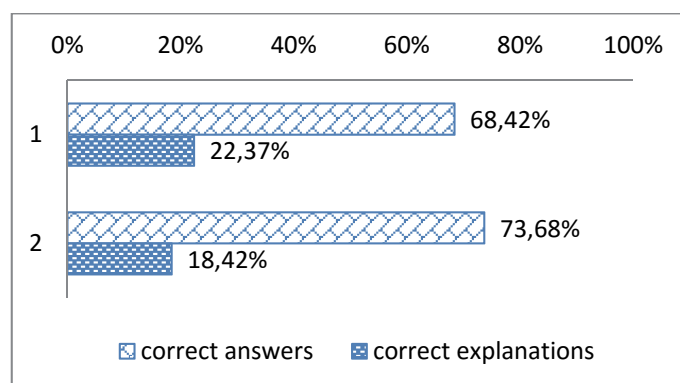


Figure 3: The correct answers with correct explanations.

We were interested especially in explanations of those students who answered the Q1 questions correctly. Their answers to Q2 questions (the arguments) were classified into 5 categories (Table 2). The number of correct and partially correct answers (with errors in formulations or not using the formal terminology properly) was rather small (29%). Those students did probably think of their answers, not choosing them on a random basis. The other 24% of students were able to determine the grammar type, though they answered the Q2 questions with a definition of the LL(1) grammar instead of writing an argument (the application of a definition was needed). Nevertheless, as they knew the formal definition, their answers to Q1 questions may also be grounded in knowledge. Approximately 10% of students skipped the Q2 questions without providing an explanation. For this group of students, it was not possible to identify the reason. They could choose randomly or were not able to formulate the argument. Those students whose arguments were found incorrect (35%) demonstrated their misconceptions of the LL(1) grammar term.

Table 2: Explanations associated with the correct answers.

Category	Proportion of students
correct answer	22%
incorrect answer or misused terminology	7%
answered with definition	24%
no answer	11%
incorrect answer	35%

## DISCUSSION

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The two case studies gave examples of two different learning activities based on real-time response processing with a CRS. Let us discuss their pedagogical benefits and technological aspects:

*Pedagogical benefits:* The first case study focused on enhancing the active constructivist and collaborative learning during lectures by combining “quick question” with “collecting ideas” – two types of activities from the suggested taxonomy (Table 1). Data recorded during the implementation phase confirmed the positive pedagogical effect of this teaching method. The students’ level of understanding was increased rapidly when they were all repeatedly challenged to respond to questions through smartphones and consider various solutions. In second case study, we described a more traditional form of applying a CRS, namely for implementing an asynchronous individual testing by using personal computers. The learning outcomes were not influenced directly. Nevertheless, the results of such interactive testing informed all participants about the actual status of knowledge what was useful for planning the next actions.

*Technological aspects:* In a lecture hall without computers, students used their personal mobile devices together with the existing Wi-Fi connection to join the process of interactive questioning. Their answers were collected, processed, and visualized as they happened by the popular Socrative system. This web-based CRS accords with the BYOD policy perfectly and provides a highly intuitive interface for both types of users, teachers and students, making them completely free to teach and learn. The second example of applying the Socrative CRS was rather traditional because nowadays, the electronic testing is widely used as an integral component of the complex e-learning solutions. The Socrative CRS also enables teachers to create, save, share and realize interactive quizzes (tests). The reports (whole class, individual student or question specific) are generated automatically containing valuable data about the results as well as the progress of all implemented activities. The live visualization of results being aggregated during the testing procedure may be used to stimulate the students’ efforts e.g. during competitions.

## CONCLUSION

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The CRSs can help teachers to improve their instructional methods towards more learning and less teaching strategies. In our opinion, the most valuable contribution of the automated processing of answers is the possibility to adjust the ongoing instruction to the learners’ needs. The instant feedback on actual level of comprehension may reveal serious misconceptions and should affect subsequent discussions or explanations. Beside the aspect of efficiency, students naturally tend to be more engaged when using the interactive digital technology in school settings. Students can reflect on their own learning more frequently, what is likely to increase their intrinsic motivation as well as strengthen the feel of responsibility. The positive experience with using a CRS during lectures and seminars, that we presented in this study, could encourage other teachers to innovate their instruction in a similar way.

## ACKNOWLEDGEMENT

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This paper was published thanks to the financial support from KEGA grant agency of the Ministry of Education, Science, Research, and Sport of the Slovak Republic provided for the project *Mobile Technology in Schools for the 21st Century*.

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# Web Applications as Possible Replacement of Software for Interactive Whiteboards

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## Abstract

*Interactive whiteboards are used in education is already quite common. Almost every school in the Czech Republic has at least one interactive whiteboard, tablets or similar modern technologies. Trends of today are clear - to include the teaching of modern technology so effectively that students and pupils enjoy learning and using modern technology to learn the material faster and more efficiently than when using other methods. But involving these technologies into education also carries pitfalls - in the first place are the technologies themselves, their cost, installation, operation and last but not least, it places high requirements on teachers to get used to new technologies and integrate them well and quickly into education. We must also consider compatibility problems that can occur when using different software and possible hardware problems with connecting various devices, it is sure that teachers can be frustrated by their work. But there are applications that are free, do not require installation and can be cross-platform. This article aims to explore the possibilities and abilities of selected web application SMART Notebook Express, A Web Whiteboard (AWW) and the Web Whiteboard software. Our aim is to determine whether these applications are able to replace some installed tools for creating interactive content on the interactive whiteboard or whether they can be used more as a supplement to teaching with modern technologies.*

## Keywords

*Education. Web whiteboard. SMART Notebook Express. Interactive whiteboard.*

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## INTRODUCTION

The modern information society improves and develops from year to year. Not only ordinary people, but especially the great amount of teachers are required to have various skills to control the current computer technology. Today's teachers must be able to include modern technology of the 21<sup>st</sup> century in education. These technologies penetrate all fields of human activity as well as in the educational process, which is strongly emphasized. Now, thanks to modern technology, education is more attractive and enjoyable for students. Original blackboard with white chalk were almost replaced by



whiteboards with colour markers. These whiteboards are slowly being replaced nowadays by interactive whiteboards, which are becoming more and more popular. These interactive whiteboards are the ideal combination of classic boards and computers. Enabling a wide range of activities and changing the traditional way of learning to teach constructive, active and especially with multimedia. Thanks to these technologies, students get new way of perceiving the educational materials and the acquisition of knowledge and skills. For teachers, these technologies can often simplify the presenting of educational content. They can also attract the attention of students more by using interactive whiteboard in education. (Burgerová et al., 2013)

However, to buy and place an interactive whiteboard involves some complications. Leaving aside the fact that it is necessary to properly place the board, choose the appropriate size and consider the possibility of changing height of the board with use of sliding rails, comes the problem in coping with educational software and especially with its operation. Many professional software designed for use with interactive whiteboards have a higher price than school can afford. Some software licenses do not allow teachers to use the software on home computers so that they can make preparations. For this reason, teachers often seek suitable alternatives with respect to the type of device and operating system, as it is nowadays quite common issue to use for their daily activities (thus to prepare for school, work) laptop, tablet or smartphone and a variety of operating systems.

Find a suitable software that would be cross-platform, easy to use and, if possible, free of charge, appears today still a bit of a problem. Although the software alternatives exist. A typical example is a SMART Notebook Express, the online free version of the professional software SMART Notebook from SMART Technologies. Another application is Web Whiteboard, which is an online application for interactive whiteboards. Popular is also a program A Web Whiteboard, abbreviated simply AWW.

The aim of the research is to compare the above mentioned web applications according to predetermined criteria to determine which and under what conditions is the most suitable as a substitute for paid applications. Are the above-mentioned programs truly cross-platform? Is it possible to use selected applications on different devices besides computers? Can teachers work with them efficiently and make preparation for students? As a research method, we establish a comparative analysis.

## **THEORETICAL BACKGROUND**

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Speaking on the interactive whiteboard, we mean a large interactive surface to which it is connected to a computer and projector. But it can also be a large screen with touch screen. Projector projects a computer image onto the surface of the board and the user can finger through it, use special pens or other instruments to operate a computer, or work directly with the board (Černý, 2015). Interactive whiteboards in its basic essence, lets you control any software that is currently running on the computer, save notes written on her desktop computer to control, generate presentation or forged material in a special software.

But so far, we are still talking about the control of the interactive whiteboard itself through a screen and possibly through a special software. But there is also software that run directly from the web browser and does not require any installation. These online

tools will be discussed in our article. In the use of Web applications that do not need to install and are available for all devices for free, we see the future.

If the application provides the user with something extra, such as desktop sharing and an option to work with other people in real time, it is a really good tool that is useful to classify for teaching with modern technologies.

## **CURRENT STATE OF KNOWLEDGE**

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If we talk about the interactive whiteboard and selected software to use, we have to ask one of the basic issues namely, to use or not to use the interactive whiteboard in the classroom? There are many enthusiastic users, as well as opponents of this technology. It is certain that modern technology itself does not turn students and the teachers into geniuses. It can bring joy, moreover also a lot of worries, the necessity of installing over learn the handling software to prepare materials and real inclusion in education. Many of these applications are not cross-platform, so they dictate us what equipment to use when we need to work with them. It is certain that if the teacher understands the use of interactive whiteboards, there is a high potential to enhance the quality of teaching, help in achieving goals and increase the attractiveness of teaching material. On the other side of a teacher who does not know how to operate this technology or will be badly prepared, the improper use of the interactive whiteboard on the contrary, increase the passivity of students instead is activated and properly motivated. Poor use of the possibilities of interactive whiteboards is a didactic negative. Even if the teacher is prepared at home for hour (assuming it has the appropriate software and at home), often does not fully exploit all the opportunities that the software brings. We also need to take into account the fact that investment in interactive whiteboards and software is often increased with costs for the training of teachers. Additionally, schools are often equipped with different interactive whiteboard and thus different software, so it is necessary to find a suitable alternative that could unite them all. Additionally, aging equipment and software is getting obsolete relatively fast. For many software updates is the need to pay (Učitel'ské noviny, 2012). These are issues that must be taken into consideration in finding a solution. Finally, it is the common problem with compatibility software on the device, or the license terms, which are often adjusted so that the teacher can use the software only on certain types of equipment and for each extra use, school has to buy extra license. Also, we take these issues into account when finding suitable alternatives to the use of interactive whiteboards. Alternatives can also be used without an interactive whiteboard. But the criteria are chosen primarily for use with interactive whiteboards.

## **THE PROJECT**

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The aim of the research is to compare the web application SMART Notebook Express, Web Whiteboard and a program with a similar name A Web Whiteboard (hereinafter AWW) and find out which program is consistent with our stated criteria, and which would be most suitable for use both at home preparing teachers and within the classroom. The criteria we set the first of these points:

- Cross-platform software.

- The possibility to create multimedia content.
- Insertion and play back of multimedia content (e.g. video, audio).
- Software contains or otherwise offers the possibility of animation.
- Does not require installation.
- Free use.

### Characteristic of selected applications

**SMART Notebook Express** (<http://express.smarttech.com>) was developed by SMART Technologies. This minimalist online version of SMART Notebook is available for free. It is primarily intended as a viewer of any documents from the SMART Notebook (ZS Vltava, 2011). This web application allows partially edit the document, but it offers just basic editing tools. There's no need to install the application, simply run it from a Web browser (tested on Google Chrome and Mozilla Firefox). However, since the application works through Adobe Flash Player, it can not run from a Web browser on a mobile phone running Android or iOS. For this reason, the application does not meet the cross-platform criteria. The application environment is very similar to the desktop version of SMART Notebook version. A teacher who knows how to use the desktop version, it will be able to work with this application as well.

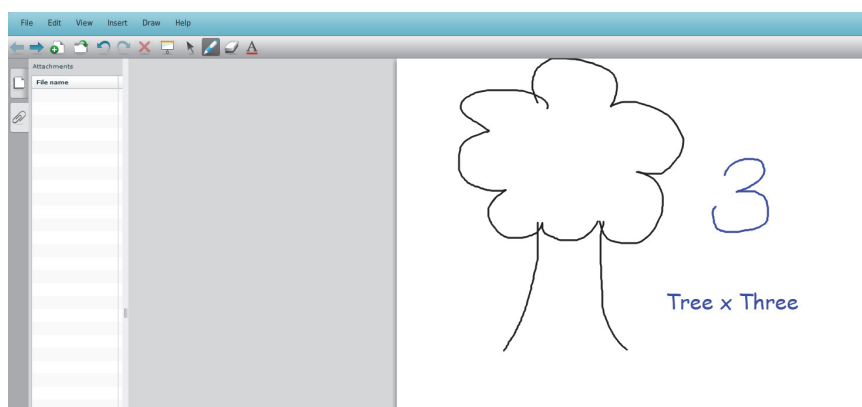


Figure 1: SMART Notebook Express: basic environment of web application

This application is rather a viewer or a simple Web whiteboard that allows to draw, erase and write the text. The file can be saved as "Notebook file" (the same format that uses desktop version of SMART Notebook). Regarding our other requirements, video can be inserted only as a hyperlink. It is also not possible to create new multimedia content with this application. However, if we open a ready-made materials in the desktop version of SMART Notebook, we can use many nested elements, including interactive (e.g. 3D throwing dice), which are in materials. The program does not require installation, it is possible to play some external multimedia elements from the SMART Notebook. Application is free for use. Although at first glance it can not do so much (compared to desktop version), teachers might consider it appropriate in many cases – for example, if the materials are made in SMART Notebook, but teacher go to teach in the classroom, where SMART Notebook is not installed.

**Web Whiteboard** (<http://www.webwhiteboard.com>) is an online application that allows cooperation of multiple users in real time. When launched, application generate

hyperlink that user can copy and send to other users in order to allow them to access shared whiteboard. Users can collaborate in real time and edit documents directly on this web application. This is a very simple tool that allows teachers to write and draw with the other users on shared whiteboard in real time. This feature can be used to involve students into educational activities. For example, students can connect to shared whiteboard from their tablets and can collaborate in real time. This tool was created by author Henrik Kniberg and this is a beta version (2016), but is completely stable. The tool is optimized for instant access and ease of use. Its appearance is simple and the entire application is user-friendly. The author states that the best use is to create notes together, sketching and planning. Web Whiteboard requires no installation, it can run directly in web browser. It is easy to use without any prior preparation, because its operation is very intuitive. It does not have the advanced tools, but allows user to write, draw, insert images directly from the Internet (drag and drop).

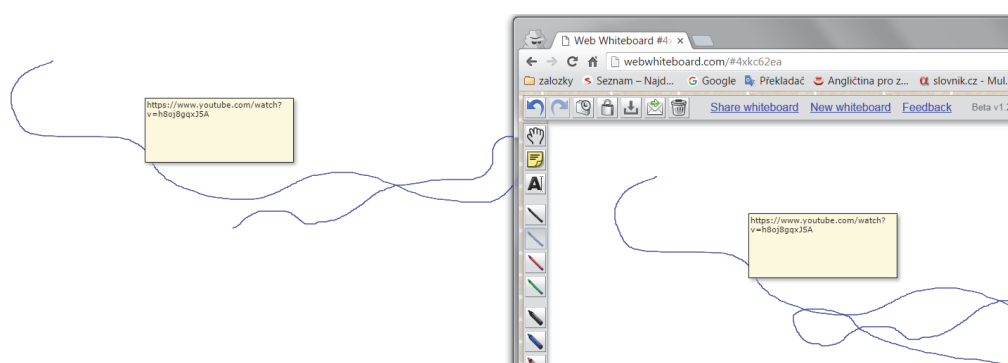


Figure 2: Web Whiteboard: users can work simultaneously in real time

Video can be inserted only as a web link. Animations can be inserted from the Internet, in the form of an animated image. The application is still in development, some options (such as password protection of whiteboard, ability to view previous version of whiteboard, or sending created whiteboard by e-mail) are not working yet, but author is working on them. The application offers the possibility to export created materials as image and download them. Unfortunately, this feature did not work when we did our comparative analysis. Of course for drawing and working with an interactive whiteboard, there are other and better tools. But not every tool is so intuitive, fast, and does not, for example, manage text, insert images directly from the Internet via drag and drop (which we consider a very handy) and particularly low when such application enables collaboration with multiple users in real time. The application contains a short videotutorial. As for the writing itself is concerned, we consider very positive that the user can select either of writing classical text directly onto a blackboard (with transparent background) or writing notes on "sticky notes" which user can move as with classical paper notes. The tool is yet available for free, but in the future, according to developers, there will be premium version with advanced features in near future (Kniberg, 2016). Regarding the application on multiple kinds of devices and a mobile phone with Android OS 5.1.1., application works (tested on Google Chrome web browser). It is not optimized for mobile devices, so working with it is a bit annoying, depending on screen size. But it is possible to work with it the same way as on computer, only with less user comfort (see figure 3). As well it works in Safari web browser on iPad. For quick notes, planning or interactive

whiteboard, where the results can be displayed in real time, all students on their devices, it's absolutely perfect web application.

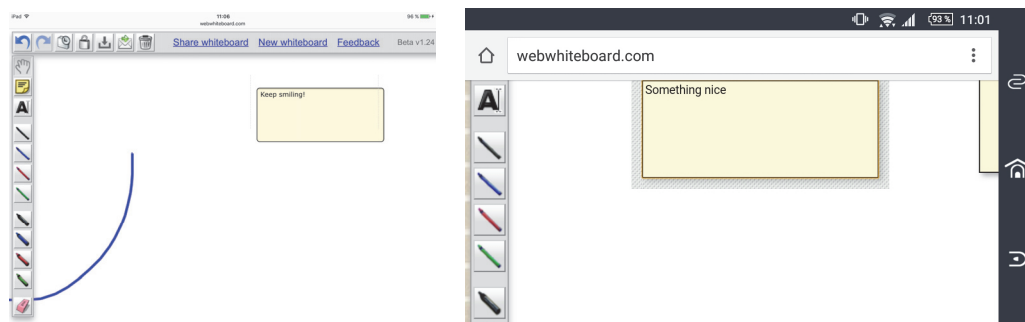


Figure 3: Web Whiteboard: application displayed on iPad (left) and Sony Xperia Z3 Compact (right)

A Web Whiteboard (<http://awwapp.com>) is an online application. It does not require installation. It runs in web browser on computer and mobile devices. This application allows users to share virtual whiteboard and collaborate in real time with multiple users. Although it does not support inserting images via drag and drop as the previous application, it offers users extra features like chat, which is useful if teacher want to communicate easily with students that are not in the classroom. Author of the application describes it as a quick tool for generating discussions and kolaborování on various projects in real time through a shared interactive whiteboard. The tool itself is quite minimalist. It allows users to draw (with a different pen thickness and color), edit text, insert images from disk, to rotate an image, remove all items through the trash icon (erase board one click). Users can share the whiteboard with each other. The big advantage is that the resulting image can be immediately downloaded for free, with no watermark. It is very easy to share whiteboard with help of generated web link (A Web Whiteboard, 2016).

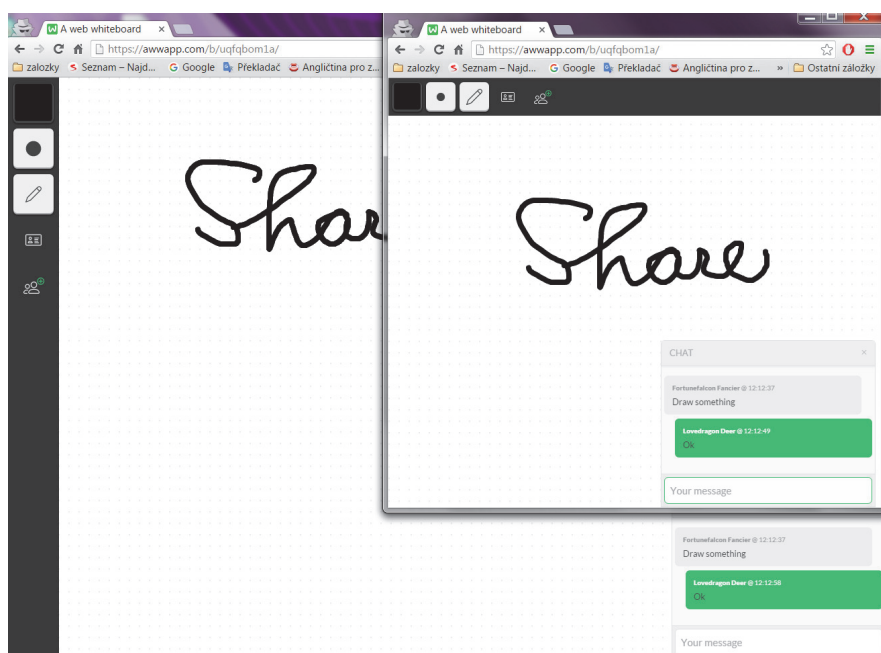


Figure 4: A Web Whiteboard: sharing virtual whiteboard with multiple users

Users who are invited can be named, which is big usability advantage. For example, teacher can keep track of who did what and what he writes in the chat (if teacher does not rename user, the application generates name automatically). It is also possible to create an account in the application. The account is free and provides the option of saving work in progress, watch progress of invited users and other premium functions. Author of the application indicates that the application is usable on a smartphones and tablets (A Web Whiteboard, 2016), which we can confirm. With Android OS 5.1.1. application works very well (tested on Google Chrome web browser, mobile phone Sony Xperia Z3 Compact). As well it works with applications through the Safari web browser on iPad (see figure 5).

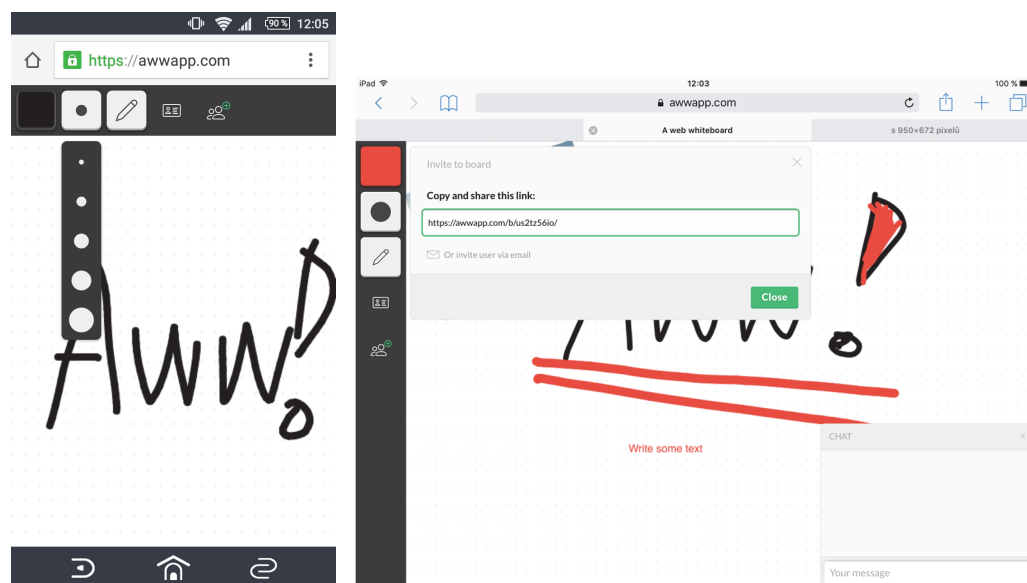


Figure 5: A Web Whiteboard on Android (left) and iOS (right)

## Comparative analysis summary

Research results are summarized in table 1. SMART Notebook Express is a big plus in that it is known and is able to view files made in SMART Notebook. Web Whiteboard is an application that enables easy uploading images directly from the internet via drag and drop, which we see as a significant simplification of work. AWW application has a built-in chat module and user can immediately download as image into computer. Main disadvantages of SMART Notebook Express are following: it is inherently mainly file viewer for SMART Notebook, moreover, is not cross-platform, only works in a web browser on a computer, since it requires Adobe Flash Player. In contrast, the other two tested web applications are cross-platform, user can handle them easily on smartphone or tablet and on different operating systems. Those applications require only a web browser and an internet connection. The big plus of these applications are that are able to share virtual whiteboard, in which we see a lot of potential for teachers and students.

Table 1: Summary of comparative analysis of selected applications.

	SMART Notebook Express	Web Whiteboard	AWW
Works in MS Windows	Yes	Yes	Yes
Works in Android	No	Yes	Yes

<b>Eorks in iOS</b>	No	Yes	Yes
<b>User can create own multimedia content</b>	No	No	No
<b>Can view multimedia content</b>	Yes	No	No
<b>User can use animations</b>	Yes	Yes	Yes
<b>Application does not require installation</b>	Yes	Yes	Yes
<b>Free use</b>	Yes	Yes	Yes
<b>Online collaboration (sharing virtual whiteboard in real time)</b>	No	Yes	Yes

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## CONCLUSION

Web technologies are nowadays beginning to increasingly use. No wonder, their use is fairly simple. The only thing the user needs to have is a web browser and internet connection. There are a plenty of applications that simulate interactive whiteboard on the internet, but not every application is suitable for use in educational process. It is clear that we must take into account the fact that "online whiteboard" does not offer users the space to create their own multimedia content. On the other hand, even in its simplicity, these applications are able to simulate the whiteboard without affecting its normal application. These applications also include basic tools, known from world of interactive whiteboards (colour markers, eraser etc.).

Tested applications described above proved to be usable all, even if each of them in another way. All of the tools are working on the computer, and besides SMART Notebook Express also on smartphone or tablet. All tools do not require installation and are available for free. Two tested applications (with exception of SMART Notebook Express) support sharing of virtual whiteboard. We consider this one of the key features of instruments that should simulate the interactive whiteboard. The possibility to use application on different devices and operating systems is also very important for teachers and students. For these reasons, we consider SMART Notebook Express insufficient, and therefore we recommend it only as a supporting tool in schools, where they have a whiteboard by SMART Technologies. On the contrary, the other two applications examined, we would recommend to anyone who needs a fast, cross-platform tool for writing notes and online collaboration in real time. Although neither of these applications are able to essentially replace the installed professional software for creating multimedia content for interactive whiteboards, they can partially replace these professional application or serve as their supplement. As a complementary software involving modern technology into the classroom or as a convenient and effective tool for teachers and pupils, intended to cooperate or interactive lessons are clearly appropriate and useful.

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## ACKNOWLEDGEMENT

This paper has been supported by: Specific research project of University of Hradec Kralove, Faculty of Education in 2016 and Specific research project of University of Hradec Kralove, Faculty of Science in 2016.

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# The Use of ICTS in Ukrainian Technical Universities

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## Abstract

*The article analyzes academic teachers' and educational management's responses to a poll on topical issues of introduction of electronic education in Europe, and in Ukraine in particular. This issue gains special prominence due to the ongoing changes in the educational system of Ukraine, due to the current web-based challenges to higher education and acute need to improve the quality of higher education. The poll represents an instrument of research into aspects of e-learning within European project IRNet – "International Research Network for study and development of new tools and methods for advanced pedagogical science in the field of ICT instruments, e-learning and intercultural competences". In particular, the article looks into to current shape of ICT competence of university professors in an average Ukrainian university and the scope of their ICT use in education. In this study a worrying number of professors self-evaluate their skills as modest. Thus, current state of ICT use by university professors and educational management could be gradually improved by the introduction of standards for ICT competence at a national or institutional level, both for the academic staff and the students.*

## Keywords

*IRNet research. Higher education. ICT tools. ICT competences.*

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## INTRODUCTION

One of the priorities in modern state policy on education is to form a unified information and educational environment both for secondary and higher education. It should be noted that the informatization of education in the context of modern life requires significant changes in the organization of educational content, its forms and methods, and most importantly - the development of innovative approaches to learning activities which "leads to expansion, intensification, integration of disciplines or separate units" (Volyarska, 2012).

The use of information technologies in educational process promotes the upgrade of computer literacy and communication skills for both the students and academic staff of higher educational institutions.

Modern educational institutions are in need of skilled workers of new generation who have research potential and are motivated for scientific innovation.

Professors' competent use of ICTs in teaching exercises stronger influence on shaping the creative potential of students. In these conditions professors start to play a more significant role in the educational process, organizing students' independent learning. The ability to carry out the selection, structuring and evaluation of information and cooperation skills with students and colleagues, aided by information exchange leads to improved efficiency of educational activities.

All the above mentioned problems are the focus of research within the European research project IRNet –“International Research Network for study and development of new tools and methods for advanced pedagogical science in the field of ICT instruments, e-learning and intercultural competences”, where we are honoured to participate (Kommers et al, 2014).

The goals of the project are as follows:

- to set up a thematic multidisciplinary joint exchange program dedicated to development of new tools for advanced pedagogical science in the field of ICT instruments, distance learning and intercultural competences in EU, Australia, Ukraine and Russia;
- to strengthen collaboration between the EU and third country institutions through mutual secondments of researchers.

The project is divided into 7 working packages (WP). One of the research packages (WP3) is entitled «Analyses and evaluation of the ICT level, e-learning and intercultural competences development in every participating country».

More detailed tasks of WP3 can be stated as follows:

Task 3.1: The main task of WP is to elaborate a system of instruments which will be appropriate for application in every country participating in the project, and will allow to obtain reliable and comparable data about ICT development, e-learning, teachers' and students' practices and attitudes towards ICT in their learning and professional life as well as their intercultural awareness. Investigation embraces domestic and foreign experience in the field of distance learning and the use of remote forms of education and IT technologies in preparing contemporary specialists, in particular future teachers. It includes identification and theoretical justification of the basic principles, forms, methods of effective use of ICT and remote forms of teaching in the educational process in higher education institutions.

Task 3.2: Comparison of the data obtained with the information elicited and generalized at the previous stage about the legal, ethical, human, technological and social factors that will help to discriminate factors influencing ICT and e-learning competences and intercultural awareness. Instruments supposed to be implemented are interviews of students, teachers and administrations of the institutions, observation over the learning practices, analysis of teaching and learning downloads and teaching materials, courses and their curricula, testing of students' learning outcomes, etc.

Now there is a significant growth of scientific interest in researching the use of ICTs in educational process. Such scientists as Hurevich P.(2012), Kademina M.(2011), Konevshitska O. (2014), Naumenko O. (2007), Shahina I.(2011), Sinko Yu. (2012), Volyarska O. (2012) and others dedicated their research to that topic.

Modern researchers have paid considerable attention to the use of ICTs in the educational process of higher education, they develop model of effective use for ICTs and distance learning technologies, focusing on training future teachers to use ICTs in learning. In this respect particularly relevant are the research and developments of M. Zhaldak, O.Zymina, L. Kartashov, N. Morze, V.Monahov, Yu.Ramskiy, N. Talyzina and others.

Y.I. Sinko notes that the main reasons why university teachers do not use ICTs are psychological barrier (difficulties in gaining computer literacy, lack of positive experience with computer-oriented technologies during the classes); low level of economic culture and disinterest of teachers in its use (Sinko, 2012).

Particularly interesting are the works of N. Morze, who focuses on the analysis of various aspects of professors' information and communication competencies. Specifically, her research is into the interplay between the quality of educational environment and the level of ICT competence of teachers, also into the developing the model of corporate standard and monitoring tools to assess Masters' ICT competence (Morze, 2014; Skalka et al., 2013).

In educational institutions around the world there are being developed, improved and implemented the standards for ICT literacy, there are being formed and used for learning modules, that permit to shape students' ICT competences during the course of study and remotely, outside the classroom.

In view of the need to improve the quality of higher education, it is becoming more and more vital for university professors to improve their own ICT competence, this would enable them to implement new and effective teaching methods and could bring the learning process to a new level.

The aim of our study is to analyze the current shape of ICT competence of university professors in one Ukrainian university and the scope of their ICT use in education. The more detailed objective was to estimate the importance of teaching goals reached by professors in their use of electronic educational resources; the scope of professors' ICT use in their teaching activities; professors' competence when using various kinds of electronic educational resources in a technical university. In this study we also aimed to identify problems and ways of their further solution as to the creation, implementation and maintenance of electronic educational resources within the teaching practices of Dniprodzerzhinsk State Technical University. For other aspects of the surveyed topic see (Nakaznyi et al., 2015).

## **METHODS**

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For such sociological research a special questionnaire has been developed by the IRNet scientific group and uploaded onto the website of the Silesian university in Katowice, which is the coordinator university for the IRNet project (The IRNet WP3 questionnaire), the English version can be found here <https://el2.us.edu.pl/ankiety/index.php/494253/lang-en>.

The questionnaire contained 19 questions, which were devoted into four main thematic units:

- the use of ICTs in educational activity;

- the use of ICTs in scientific research;
- further education, professional growth;
- the understanding of ICTs in education, computer literacy

Most of the questions are multiple choice questions, the rest of them demand gradable answers.

According to this questionnaire in April and May 2015, University professors and management of the institutions involved in the project IRNet in general, and DSTU in particular were anonymously questioned.

The numerical results of the research and analysis enabled us to define some of the most actual problems of electronic educational space and identify the scope of teachers' use of ICTs, which in the future will influence the creation, implementation and operation of e-learning system in DSTU. The choice of academic staff of DSTU as object of study is due to the fact that this educational institution is an average university in Ukraine, which allows extrapolating the results of the analysis on a wide range of universities of Ukraine.

The results of research and analysis made it possible to evaluate which ICTs the professors use in teaching and what are the reasons and consequences of the use of ICTs.

The object of our study is Dniprodzerzhinsk State Technical University, which is the participant of the IRNet project, besides, it is on the 140th place among 293 universities in the Webometrics ranking of higher educational institutions of Ukraine. Its characteristics present it as an average university of Ukraine, allowing to speculate about the possibility of extrapolating the results of our research on a wide range of universities in Ukraine.

The study was attended by 53 teachers of the university, including 47 respondents representing academic staff and 6 were the heads of the university and its departments.

## **RESULTS**

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Analyzing the use of ICT by teachers of technical higher educational institutions, we tried to focus primarily on the information tools of the teacher during lectures and practical teaching, namely the presentation of any information in the classroom, the use of computer-based testing, sharing information via email, and more.

At the same time we did focus on professors' personal creation of electronic courses and their systematic use of ICTs in the teaching of assigned disciplines.

We paid special attention to the development and support of open educational resources which help determine whether professors hold open university courses or have individual open educational resources (e-portfolio) and so on.

Among the first questions in our study the professors were asked to evaluate their readiness to use ICTs in teaching (Figure 1). In this question of our survey respondents had to rate the presented levels of ICT use e-resources according to 5-grade ranking system, where 5 is the highest point. So each of the resources has five columns, representing 5 marks, ranging from 1 to 5.

As you can see, 66% of teachers acknowledge the necessity to use information-communication tools in their teaching. Out of these 66% of people 38% are fully aware

that it is information and communication tools that are urgently needed in their teaching activities; they are a prerequisite for improvement in current system of teaching, 28% of professors are almost sure of this, and only 21% of teachers are only now starting to acknowledge this.

It should be emphasized that in general contemporary teachers understand the need for extensive use of information-communication tools in their teaching activities.

However, a fairly high percentage of teachers, which is more than 21% said that the information tools in teaching university courses enable them to present course material in the

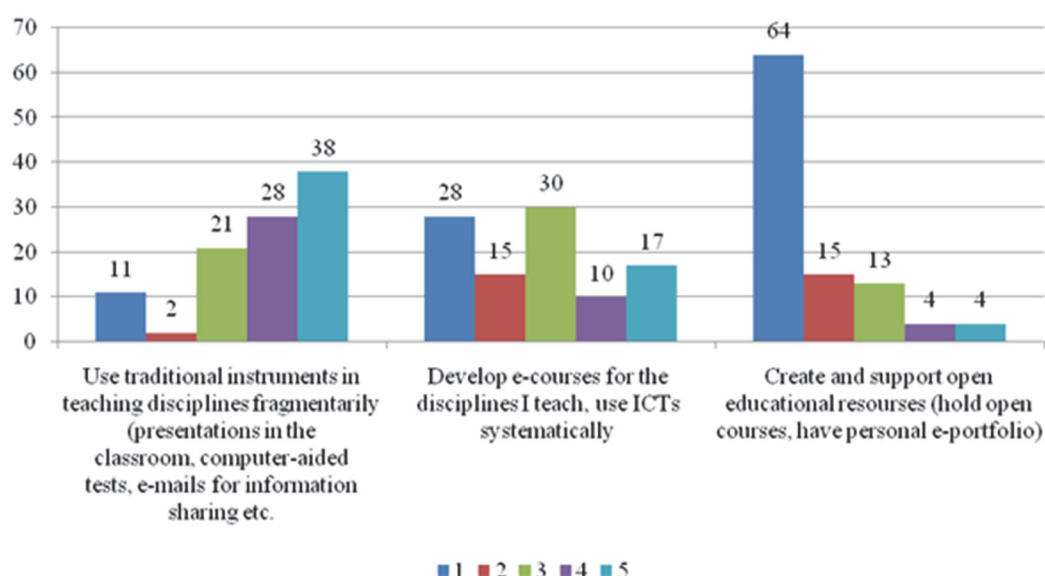


Figure 1: Self-evaluation of use of information and communication technologies by university professors (in %)

classroom, to provide a variety of computer-based testing, to ensure the exchange of digitalized information, but is not mandatory and can be used in the classroom at the request of the teacher.

Things look less optimistic when we analysed systematic use of information technology in the practical work of academic staff, mainly the development of electronic courses in the subjects, personally taught by the professors. The percentage of professors who personally develop e-courses on specific subjects, using them systematically in their practice, is 28%. We must stress, that 31% of teachers are close to a positive result. It is rather worrying that there's a rather high percentage of teachers (which is 28% and 15%, equalling to 43%) who do not pay enough attention to systematic use of ICTs during lectures and practical classes and do not see the significance of their own technological developments in teaching process.

The situation looks even less optimistic when we analyzed the creation and support of open educational resources by teachers of higher educational institution. Especially worrying is the fact that the majority of teachers evaluated their skills of developing and supporting educational courses, created by them very low - 79% in all (64% of respondents gave the lowest point 1, and 15% gave 2 points only). Only 8% of teachers

(with 13% of respondents nearing that level) point to the need of creation and development of open educational resources, personally conduct open courses, have their own open educational resource. The total number of such respondents is about 21%.

It should be stressed that the main problem of failure of academic teachers to use ICTs in their practice is psychological barrier. First of all, it is the barriers to gaining computer literacy, teachers' lack of accumulated positive experience in the practical use of computer-oriented technologies during lectures and practical classes. Finally, it is low level of personal culture, lack of interest of university teachers in ICT use (Sinko, 2012).

We tried to explore how academic teachers use different types of electronic educational resources in their teaching activities, based on their own digital materials to support classes (presentations, demos, etc.); independently developed digital educational materials for students' independent work (digital textbooks, assignments, tests, etc.); elements of virtual laboratories (computer models to identify ways of solving a number of problem tasks and research objectives); electronic textbooks, books (university library, public library, etc.) as a recommended primary resource; electronic tutorials, textbooks recommended as an additional resource; annotations of updated publications that are relevant to a particular discipline (including publication, prepared jointly with students); thematic sites; educational programs; some digital media training facilities; media objects (fragments of films, radio programs, etc.); personal output of electronic courses using distance learning platforms (e.g., MOODLE); resources of scientific data, which can be accessed by higher educational institution as well as electronic resources coming from project activities of students; University repository of electronic resources and more.

Using Figure 2, let us consider how academic teachers use a variety of electronic educational resources in their teaching activities.

As we see, the university teachers prefer self-developed digital materials that are used to support lectures and practical seminars (83%). They are mainly of presentation and demonstration nature.

Quite high number of professors (which is 73.6%) independently develop digital educational materials for classes just for individual students' complementary work: independent development of digital textbooks, assignments and test materials. Professors also quite massively use electronic tutorials, textbooks both as an additional recommended resource (66.0%) and primary one (54.7%) in their educational activity.

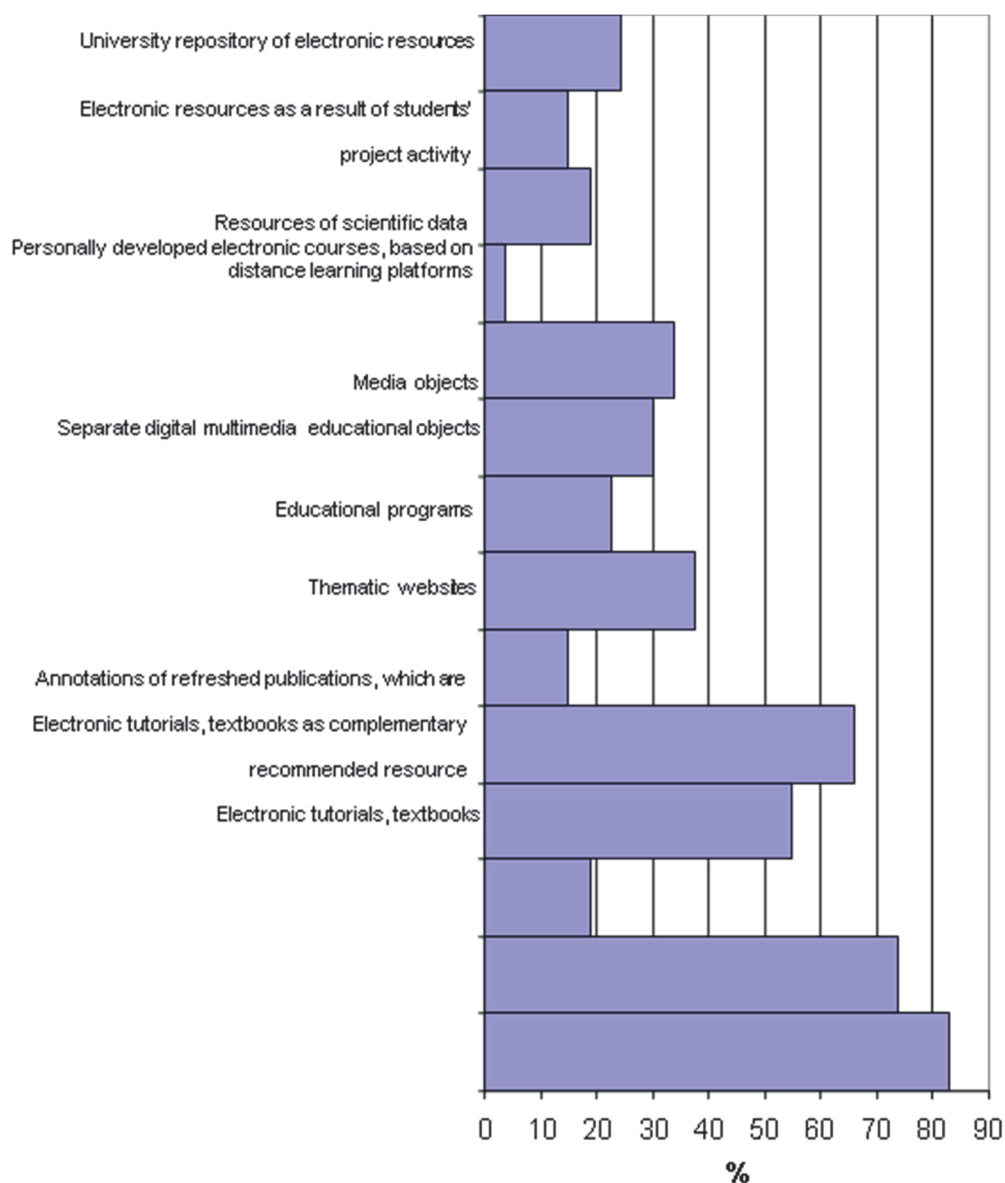


Figure 2: The use of various types of electronic educational resources in university professors' teaching

Of course, in modern conditions of informatization in higher education students' individual independent work improves to a new level - the quality of higher education can be improved in a large number of ways. Creative thinking, the selection of individual mechanisms for obtaining knowledge through information-communication technologies should all be taken into account by the academic staff of the university.

It should be emphasized that the main focus of university teachers is still on the use of fairly common types of electronic resources such as: thematic websites (37.7%); media objects (using fragments of films, television and radio programs - 33.9%); some digital multimedia learning objects available to the public (30.1%); and, of course, training programs (22.6%).

Significantly lower are the points given by university teachers to the use of a variety of electronic resources in teaching: the use of University's repository of electronic resources (24.5%), the use of elements of virtual laboratories (18.8%), accessing the scientific



databases to which the university is subscribed (18.8%), use of electronic resources based on results of students' project activities and support of publications, created in close collaboration between teachers and students (15.0%).

## **DISCUSSION**

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Analyzing the use by university teachers of various kinds of electronic educational resources in their professional activities, we paid attention to the fact that only 3.7% of teachers recognize the importance and necessity to independently develop electronic courses using distance learning platforms (e.g., Moodle).

It should be emphasized that the use of a variety of information and communication tools in a higher educational institution is only possible if both the students and the professors are consistently and seriously motivated: the teacher should be aware of the level of ICT knowledge the student should have got before starting his university courses, while the student should be aware that the results of his work, aided by the use of ICTs, will be needed in his future professional activities. As it is stated by N. Morze, for the motivation to start working both ways – from the students' and the professors' side – there should be a national standard of ICT competence for both groups. In a situation when they are still being developed at a national level of Ukraine, it is wise for the universities to develop and approve their internal standards (Morze and Buinytska, 2014), (Morze and Kocharyan, 2014).

## **CONCLUSION**

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Thus, the improvement of the use of ICTs by academic staff of higher educational institutions of Ukraine has the following prerequisites: total awareness of the need to improve the quality of higher education, understanding the role of ICTs in modern higher education, supported by proper requirements of the national or institutional level, proper state of computer hardware and networks, proper courses to upgrade ICT competence of academic professors.

All that is vital for the professors and only under such conditions we can speak about information and communication technologies in higher education and the teachers will rise above fragmentary use of ICT tools, they will not use only the ICT resources available (presenting information in the classroom, holding tests, information sharing via e-mail), but will be prompted to develop their own independent electronic courses and resources for the disciplines they teach and for the research they do.

## **ACKNOWLEDGEMENT**

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The research leading to these results has received, within the framework of the IRNet project, funding from the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Programme FP7/2007-2013/ under REA grant agreement No: PIRSES-GA-2013-612536.

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# Approach to Selecting ICT Tools for Formative Assessment

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## Abstract

*The paper presents the results of the research in the area of ICT-tools for pedagogical practices. The research was conducted within the scope of the IRNet project. One of the objectives of the project was to select ICT tools and substantiate their advantages and functionality for their use in e-learning. According to the modern approach, the continuous assessment, shaping self-guided and responsible students' activity, plays an important role in e-learning. The efforts of the group, bringing together researchers from the University of Ostrava (Czech Republic) and Herzen State Pedagogical University of Russia focused on the analysis of the implementation of continuous formative assessment by the means of ICT. The goal was to systematize the general potentiality and technological profile of ICT tools in formative assessment, on the basis of the formative assessment theory. The types of different activities and objectives incorporated in formative assessment were defined and associated with appropriate types of applications for present and online interactions. The special system of evaluation tools was elaborated within the scope of the research (i.e. the evaluation criteria and scoring rubrics). The paper also describes research prospective - using evaluation tools for the comparison of applications according to the CSEM - Customer Satisfaction Evaluation Model.*

## Keywords

*E-learning. Formative assessment. IRNet project. Evaluation criteria. Scoring rubrics. ICT tools.*

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## INTRODUCTION

A special role in blended learning is given to the evaluation system and the management of educational interactions. This is because this form of education has a high proportion of self-guided work. It is important to involve students in the management of their own learning activities, so these activities become deliberate and purposeful. To this end, students and teachers should focus not only on the results but also on the process of learning.

A number of researchers recognize continuous formative assessment as the effective means for supporting students' learning (Shute and Becker, 2010; Sargent, 2014; Pepper, 2013; Redecker, 2013). The main function of formative assessment is the support of students' further learning through feedback, which leads to the forehand correction of the educational process (OECD, 2013).

Formative assessment focuses on a specific student and is designed to reveal problems in the acquisition of educational content in order to achieve the maximum efficiency (Harlen and James, 1997). Formative assessment provides students with information about the causes of difficulties and failures, helping to develop a strategy and tactics for achieving educational goals and overcoming difficulties based on reflection, taking into account the methods and criteria for evaluation of the process and its results (Black and Wiliam, 1998; Bangert-Drowns, et.al, 1991).

As far as function and realization is concerned, formative assessment is closely related to summative assessment. In the following phase, summative assessment can be used for formative purposes. On the other hand, the results of formative assessment are often a part of summative assessment (although it may be the result of an unconscious and unplanned process).

- Feedback should provide a student with the following information:
- How far is a student from the set goal?
- What progress has a student made in learning (in cognitive, psychomotor, metacognitive, social or affective categories)?
- Whether or not a student can achieve (effectively) the set goal through the selective learning activities?
- What strengths and weaknesses characterize a student's progress toward the goal?
- What a student should do in order to achieve the set goal in an effective manner?

Webb, Gibson and Forkosh-Baruch (2013) claim that useful formative feedback needs to be provided by teachers, peers and learners themselves. These three learning process groups should work together in clarifying and negotiating learning intentions and criteria for success. Teachers should engineer effective discussion and other learning tasks, including those using digital media that elicit evidence of student understanding and providing feedback that moves learners forward. As far as peers are concerned, teachers should be activating students as instructional resources for one another – by peers support and peer feedback. Finally, learners should be activated as the owners of their own learning. This approach can help increase the validity and authenticity of assessment, which is essential for collaborative learning within the scope of the 21<sup>st</sup>-century learning.

Race, Brown and Smith (2005) captured the importance of quality formative assessment by saying: "Nothing that we do to, or for, our students is more important than our assessment of their work and the feedback we give them on it. The results of our assessment influence our students for the rest of their lives and careers – fine if we get it right, but unthinkable if we get it wrong."

The following seven principles should be followed in the implementation of a good feedback within the scope of the self-regulated learning model: 1. Clarify what good performance is 2. Facilitate reflection and self-assessment in learning 3. Deliver high-

quality feedback information that helps learners self-correct 4. Encourage teacher–learner and peer dialogue 5. Encourage positive motivational beliefs and self-esteem 6. Provide opportunities to act on feedback 7. Use feedback from learners to improve teaching (Nicol and Macfarlane-Dicks, 2006).

Addressing the issue, Royce Sadler, Professor of Higher Education, Griffith University in Australia, introduced the following idea on the future relationship between formative assessment and feedback: “Formative assessment includes both feedback and self-monitoring. The goal of many instructional systems is to facilitate the transition from feedback to self-monitoring”(Davies, 2010).

Decisions about assessment and feedback lie at the heart rather than at the periphery of the curriculum design process. Currently, four broad perspectives on learning are being discussed. Each perspective makes different assumptions about the nature of learning and suggests different approaches to assessment and feedback. These four learning perspectives should not be seen as incompatible. Indeed, learning designs for tasks, modules and programs will invariably draw on a mix of these perspectives and on their different assessment and feedback approaches. (Davies, 2010).

*The associative perspective* emphasizes that learning is about acquiring competence through concept linking and bringing together component skills. Assessment might involve both small-scale testing of basic understanding and skills and more complex assignments where understanding and skills are assessed in larger contexts (for example, through projects or work-related assignments). Feedback would involve supporting learners as they build more complex understanding and skills.

*The constructivist perspective* emphasizes that learners must actively construct their own understanding. Assessment would focus on the extent to which learners can structure and restructure material for different purposes without the help of others (for example, through inquiry-based tasks), and feedback would support learners in becoming more self-directed. Hence, this approach requires that learners reflect, self-assess and generate feedback on their own learning.

*The social constructivist perspective* emphasizes the role of others in constructing understanding. Dialogue and collaboration are seen as key to learning success. Assessment would involve group tasks and assignments, sometimes with individual contributions being assessed. This perspective emphasizes that feedback is not just teacher-provided but must be rich and varied, deriving also from peers during collaboration and discussion.

*The situative perspective* sees learning as arising from participation in communities of practice. Learners participate in many learning communities during their studies which prepare them to become members of professional communities (learning to think and act like a lawyer or an engineer, for example). This perspective is consistent with social constructivism but also emphasizes identity formation. Assessment tasks would be authentic and modeled on what happens in professional practice; feedback would involve peers, disciplinary experts and those in relevant roles and professions.

As far as university education is concerned, all the perspectives can be used (with varying intensity) even within a single study program depending on its planned learning outcomes and teachers’ preferences.

The realization methods of formative assessment differ significantly: didactic tests in all forms (knowledge tests, attitude tests, and essay tests), performance assessment, portfolio assessment, assessment through observation, paper assessment, etc. It is associated with various types of activities implemented in e-learning, with the use of ICT tools during synchronous and asynchronous interaction (Noskova and Pavlova, 2015; Noskova and Yakovleva, 2015; Cápay et al., 2011).

To find and evaluate appropriate ICT tools, we need to consider, above all, the specificity of educational activity, reflecting the current methodology of formative assessment.

Various related aspects and activities of learning are included in the assessment system that occur in the process of self-government and peer guidance. For example, motivation, associated with personal goals setting; regulation and targeting, allowing the trainee to carry out a choice of ways; planning and correction of actions; activities, reflecting the choice and implementation of specific operations in the course of learning activity (interaction with the information, means of communication, acquisition and use of computer tools and so forth).

Formative assessment does not imply an unambiguous assessment for all students of the process and the results, i.e. does not compare students to each other. It aims to help everyone finding the best way and means to achieve the objectives, i.e. the results. Through formative assessment, students must see and objectively evaluate themselves in the learning process. ICT tools can be very helpful in this case.

Generally, some or all of the following may be the benefits of technology-enhanced assessment and feedback to practice (Davies, 2010):

- Greater variety and authenticity in the design of assessments;
- Improved learner engagement, for example through interactive formative assessments with adaptive feedback;
- Choice in the timing and location of assessments;
- Capture of wider skills and attributes not easily assessed by other means, for example through simulations, e-portfolios and interactive games;
- Efficient submission, marking, moderation and data storage processes;
- Consistent, accurate results with opportunities to combine human and computer marking;
- Immediate feedback;
- Increased opportunities for learners to act on feedback, for example by reflection in e-portfolios;
- Innovative approaches based around the use of creative media and online peer and self-assessment;
- Accurate, timely and accessible evidence on the effectiveness of curriculum design and delivery.

To determine the opportunities of ICT tools for the implementation of formative assessment in e-learning in frame of the international IRNet project (Research network for study and development of new tools and methods for advanced pedagogical science in the field of ICT instruments, e-learning and intercultural competences, [www.irnet.us.edu.pl](http://www.irnet.us.edu.pl)),

we focused on the development of special evaluation tools. The paper presents the developed evaluation tools, which allow comparing and evaluating different ICT tools, and educational practices. This is important for the development of e-learning because the identical tools and software can be used in a flexible manner with the appropriate didactic support and understanding of the advanced pedagogical methodology.

Since formative assessment is a versatile process, the study was carried out taking into account different types of activities and tasks within the framework of formative assessment. On this basis, the technological profile of different groups of ICT instruments was analyzed and selection was carried out in accordance with the methodological profile and operating aspects of each activity. Elaborated evaluation tools are presented in the form of scoring rubrics, including the evaluation criteria and measuring levels. It is applicable both to ICT tools included in the LMS, and external independent software.

The process of the use of modern technology in assessment should be based on the sequence of the following steps toward effective technology enhanced assessment and feedback (Davies, 2010).

1. Applications of technology to assessment and feedback are embedded in the institutional and/or faculty vision for high-quality learning, teaching and assessment;
2. Principles of good assessment and feedback underpin the use of technology – for example, assessment designs exploit technology to motivate learning, encourage time on task, facilitate self-assessment and enable learners to act on feedback;
3. Applications of technology are informed by a clear understanding of the purpose of the task, the ICT skills and diverse needs of learners and the specific requirements of the contexts in which the assessment or feedback takes place;
4. Technology is used to facilitate enhancements previously difficult to achieve at scale such as peer assessment;
5. Optimum use is made of e-enabled assessment management and administration systems to monitor learners' progress and improve teaching and learning;
6. Technology augments streamlines or enhances current provision, and is not used for its own sake.

Formative assessment can be related with different kinds of learning tasks and training activities, so it is very important to identify the most effective and convenient ICT tools within each group of activities. This does not mean that for each task special software should be selected. A teacher should realize the methodology how to utilize each tool in a particular situation of formative assessment (Novak, 1998; Dietz-Uhle and Hurn, 2013). If the same tools are used in different ways through a flexible teaching methodology, it makes the educational interaction more comfortable. The main research task was to analyze whether different LMS have sufficient tools for formative assessment.



## **RESEARCH PROBLEM**

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In order to systematize the functions of ICT tools for formative assessment, we based our research on five groups of continuous formative assessment activities (Logvina and Roždestvenskaja, 2012):

- A.1. Assessing the needs of the students,
- A.2. Promoting student's cooperation and self-reliance for self-assessment, peer assessment, peer feedback,
- A.3. Student's progress tracking,
- A.4. Checking understanding and encourage meta-cognition,
- A.5. Demonstrating learning outcomes and reflection.

Assessing the needs of the students (A.1) suggests evaluating the motivation and desire to learn new knowledge, skills and ways of activity. It helps a teacher and a student to plan training and interaction. The main ideas are the following: a person who is learning initiates leading vector of educational strategy; variability and individualization of learning ensure needs and opportunities. The meaning of learning, according to Rogers, is not in the assimilation of knowledge, but the change of the internal sensory-cognitive experience of a student associated with his personality (Strahan and Rogers, 2012). Education should be based on "helping relationship" between teachers and students.

This requires tools that can help students to learn an educational material, to identify own interests, to help set goals and to plan learning activities. Among ICT tools, suitable for such tasks, the following ICT tools have been identified: testing systems, electronic survey systems, electronic worksheets, mind mapping.

For instance, the LMS Moodle provides the following testing facilities (question types): calculated, simple calculated, calculated multi-choice, description, essay, matching, embedded answers (cloze), multiple choice, random short answer matching, short-answer, numerical, true/false, third-party question types (<http://moodle.org>).

It is necessary to compare testing capabilities, corresponding to the objectives of this formative assessment, of the LMS Moodle with other LMSs and external applications.

The Moodle survey system provides a number of verified survey instruments, including COLLES (Constructivist On-Line Learning Environment Survey) and ATTLS (Attitudes to Thinking and Learning Survey). It is necessary to assess the functionality of other ICT tools in terms of identifying opportunities and needs of individual students. In addition, special features that allow further consideration and implementation of the identified queries need to be assessed. In the same way, the features of these instruments such as feedback (allows to create own questions to collect feedback, or non-graded questions), quiz (allows to design and set quiz tests, which may be automatically marked and feedback and/or to correct answers shown) need to be analyzed and compared. Simultaneously, Mind Mapping, a useful tool for the implementation of the designated task, is not integrated directly to the LMS, respectively, it is necessary to analyze additional services, possible to apply.

Promoting student's cooperation and self-reliance for self-assessment, peer assessment, peer feedback (A.2) is focused on the estimation of students' ability to take responsibility for their own learning, interpersonal skills, understanding feedback and

communication skills. Cooperation (Popham and Stiggins, 2007) is aimed at creating an atmosphere of trust, mutual respect, mutual understanding (especially important to increase motivation, the quality of the educational process and students' confidence in their abilities).

Through various activities, supported by ICT tools, students have the opportunity to obtain reliable information on their degree and the dynamics of growth, to participate in the development of criteria for evaluating educational tasks, to determine the prospects of construction of training activities within the scope of group work and cooperation.

An important pedagogical task is to stimulate students organizing their own educational cooperation, to involve students as essential partners in elaborating the most appropriate solutions for educational tasks and objectives.

To do this, students need to be provided with opportunities to offer each other advice about their work (peer feedback), to assess each other's work in a summative way (peer assessment), to be involved in self-assessment, self-evaluation, self-regulation, self-monitoring.

These activities help students to understand both learning intentions and success criteria, to reflect on the learning process, to act on feedback received from their teacher and their peers and thus to manage their learning. A teacher needs means and tools to evaluate students' personal activities, and students' cooperation.

The following types of ICT tools for network cooperation were identified: shared documents (spreadsheets, text documents), shared sites, blogs, wikis, organizers, and calendars.

For example, Moodle contains several tools. Workshop is a peer assessment activity with a number of options and two grades for a student: own work and peer assessments (other students' work). Forum, wiki, and database are also available. These tools represent a collection of course-specific information, a bank of entries, that allows students and/or instructors to populate, display and search information).

Several external ICT tools are widely used and recommended. Google Drive is a tool for creating and sharing different types of on-line documents. Students can use chat, comments and history of changes in every document. WordPress and Blogger are online software for the creation of a free websites or blogs. Concept board is a whiteboard type software for group collaboration.

For the evaluation and comparison of ICT tools, suitable for solving this type of problem, it is also important to have a set of functionality criteria.

Students' progress tracking (A.3) aims at comparing a student not with an "ideal" standard, but with himself. It helps students detect problems with motivation and self-organization, to reveal misconceptions. Such ICT tools as statistics and reports about different activities in e-environment, e-gradebooks, blogs, forums, interactive forms and shared documents can be used for this purpose.

LMS Moodle provides several tools for learning analytics and e-learning reporting (events monitoring, overview statistics, site-wide reports, engagement analytics, logs, completion tracking, and forum graph). They help view trends of participation, submissions and other data and can assist in improving the e-learning experience (Drlik et

al., 2014). Monitoring progress includes not only a formal promotion, but also the evaluation of progress in resolving ambiguous and open tasks. It helps identifying the need for correction by a teacher (direct interaction, instruction, information, etc.). Some optional plug-ins can be downloaded for Moodle for this purpose. For example, progress bar is a time-management tool for students showing progress in activities/resources. FN - My Progress is a tool similar to progress bar, but the information is available only for a student, not to teachers. Badges provide a tool for recognizing achievement and showing progress based on a variety of chosen criteria.

Checking understanding and encourage meta-cognition (A.4) focuses on the feedback to help students in realizing their thinking process and develop creativity. For this purpose students need tools to determine the relevance and reliability, sort, classify, highlight the main and secondary, analyze, synthesize, critically evaluate. The basic is to stimulate students to use meta-cognition strategies - develop an action plan, systematic search for and concentration on the task, extension ideas, build hypotheses, retelling, control own understanding.

Several types of ICT tools are useful for solving these problems. Among them are mind maps, whiteboards, infographics, video comments and annotations, games and quizzes and communicational tools.

In Moodle, such tool as assignments, workshop, forum, testing system can be used. Moreover, appropriate external tools such as Hot Potatoes (six applications, to create interactive multiple-choice, short-answer, jumbled-sentence, crossword, matching/ordering and gap-fill exercises), Socrative (quizzes, quick question polls, exit tickets and space exploration), MindMeister or other mind mapping tools, LearningApps (Web 2.0 interactive modules, work with maps, crossword puzzles, create maps of knowledge, creation of games) may be integrated.

Suitable tools for this group of formative assessment tasks should also be selected according to clear criteria.

Demonstration of learning outcomes and reflection (A.5) is not only a formal checking of understanding, but the demonstration of meta-cognition skills through the product evaluation activities (work and results of projects, a personal creative student's contribution, etc.). In this context, students need tools to show what knowledge they have acquired and how they can apply it in new situations. Students, furthermore, need means for solving problems which involve the studied material (e.g. give examples, interpret concepts, set intra and inter subject connections, organize material, define concept, set out the material studied in the compressed or expanded form, explain "in their own words"). Students need to demonstrate not only new knowledge and skills, but also new attitudes and traits of personality.

What types of ICT tools can be recommended? There can be applied interactive quizzes, criterial tables, tools for narration and visualization, progress and performance portfolios and other. Students need a suite of tools to organize, demonstrate, discuss, and evaluate their educational outcomes.

Wiki or exporting to portfolio tool can be used in Moodle. However, this LMS does not provide any special tool for structuring students' portfolios. Consequently, external tools can be used such as Google Sites, Blogger, integrated with other Google Apps, Rubric

Maker Tools, Mahara (an open source e-portfolio, weblog, resume builder and social networking system), Three Ring (multimedia portfolio), Animoto (gives students the ability to make a short shared video of what they have learned) and other. The biggest drawback of the external applications is the need for students to have multiple accounts. Therefore, an important requirement is the integration of the systems used, if possible.

Thus, each group has its own particular problems of implementation and requires selection of appropriate ICT tools. Since the same tool can be used for different purposes and in different educational contexts, it must be assessed in each situation in its functionality criteria.

## **METHODS**

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In order to be able to test and compare different ICT tools used in formative assessment the rubric-based approach was used. A rubric is an explicit set of criteria used for assessing a particular type of work or performance (The TLT Group, 2011). Rubrics can serve as a utility for program development and assessment and other important functions. For example, rubrics can function as a communication tool among faculty within an institution or across institutions. When shared with students, rubrics are an efficient tool for conveying performance expectations. Applied in the assessment process, rubrics serve as measuring devices for systematizing the assessment of student work. Rubrics are especially helpful when, as is often the case, the learning outcome has a subjective component. A rubric is a tool that helps objectify the assessment of subjective phenomena. A rubric provides a set of criteria developed to operate a learning outcome (Kleine and Yoder, 2011). The Association of American Colleges and Universities (AAC&U) launched applying the VALUE rubrics (Valid Assessment of Learning in Undergraduate Education rubrics) in 2007 as an initiative that is rooted in a philosophy of learning assessment that privileges the authentic assessment of student work and the development of shared understandings of student learning outcomes (Rhodes and Finley, 2013).

Scoring rubrics serve as measuring tools for systematizing the assessment of ICT tools. They provide a set of criteria developed to be applied in the determined formative assessment activities in e-environments. Rubrics are summarized in a matrix form. The dimensions form the rows of each rubric. The levels form the columns of a rubric matrix and delineate qualitatively distinct levels of its tools' functionality. The levels range from absence of the desired applicability (at the low end) to full functionality (at the high end). In all rubrics, 1 point corresponds to the characteristic "practically not applicable", 2 point "no special features". Levels 3 to 5 are formed on the principle of diversity of the instrument functions.

Each cell in the rubric matrix presents a brief and generalized description of the corresponding function. Each group of tasks has its own scoring rubric, containing 5 levels (1-5 points). However, a special group of general parameters (G1 - G6), combined in a single category, which reflects the characteristics common to all ICT tools, was allocated. These parameters are the following: G1 "Feedback", G2 "The form of assessment", G3 "Multimedia", G4 "LMS integration", G5 "User-friendly interface" and G6 "The purchase price".

In the process of evaluation of different ICT tools with the use of CSEM - Customer Satisfaction Evaluation Model, experts were invited to apply these rubrics.

Here is an example of levels for the general parameter G1 "Feedback". Functions of ICT tools for ensuring feedback are indicated as follows: automated delayed feedback, automated feedback immediately after sending data, online feedback with other participants (students, teachers). If an ICT tool combines all three possibilities, it receives a 5-point evaluation.

Parameter G2 "Form of assessment" reflects the potential for the following functions: a formalized evaluation using points, percentage, graphic; commenting or the tool enables a choice of various forms of communication about the results.

Estimation of the parameter G4 "LMS Integration" is the following: a tool integrated into LMS receives the highest score (5 points). If the integration of the tool into LMS already has special units, i.e. an optional plug-in, it receives 4 points. When specific tools for integration need to be developed when working with a tool within LMS, but it is possible, it receives 3 points. LMS with open source software does not limit the opportunities associated with the integrated use of external tools, but it is necessary to attract experts in programming.

For example, tasks prepared with a tool such as the Learning Apps, are possible not only on a website page, but also to be downloaded in an offline and SCORM formats. Using the SCORM format makes it possible to load an assignment in Moodle and use and evaluate it along with other assignments and tests. Accordingly, this instrument receives 4 points of this general parameter.

Here are the criteria that allow evaluating tools from 3 to 5 points for five of the formative assessment objectives.

*Activity A1. Assess the needs of the students.* As students have a wide and varied experience, abilities and interests to any new topic, ICT tools with special operating profile to identify and evaluate these aspects at the starting point of the learning process are required. The main purpose of the information obtained with the use of these tools is to motivate students to define the route to achieve apprehensible educational goals.

Functionality of ICT tools, which may be applied to resolve this type of problem, is described using the following categories:

- A1.S1. Assess students' opportunities (basic knowledge, skills),
- A1.S2. Facilities for planning learning activities,
- A1.S3. Assessing students' educational needs.

For example, when assessing ICT tools for A1.S3. "Assessing students' educational needs" we use the following levels (3-5 points): LMS built-in methods of educational needs assessment, LMS integrated additional methods of educational needs assessment, individual selection of educational needs assessment methods. We note here that if a tool is „not applicable“ to this type of activity, it gets 1 point and if it has „no special features“, it gets 3 points.

*Activity A2. Promotion of student's cooperation and self-reliance for self-assessment, peer assessment, peer feedback* is described using the following categories:

- A2.S1. Students' access to each other's work,
- A2.S2. Mutual commenting,
- A2.S3. Discussions, debates,
- A2.S4. Peer assessment,
- A2.S5. Self-assessment.

For example, for A2.S5. "Self-assessment" the key rubric dimensions are: facilities for formalized assessment, facilities to set assessment criteria, estimates accumulation of assessment results.

*Activity A3. Students' progress tracking.*

Tasks in this group were considered in accordance with the following categories:

- A3.S1. Tracking errors,
- A3.S2. Tracking attitude to learning activities,
- A3.S3. Tracking self-organization.

For example, ICT tools for "Tracking self-organization" are estimated as possible to perform the following functions: provide on demand information about users' activities, accumulate and report users' actions in different visual forms, analyze and guide users' actions.

*Activity A4. Checking understanding and encourage meta-cognition* includes the following categories:

- A4.S1. Facility to set assessment criteria,
- A4.S2. Facilities for transcoding information,
- A4.S3. Communication facilities,
- A4.S4. Facilities for self-diagnostics and reflecting results can be solved with the use of various ICT tools.

It is important to note experts can evaluate ICT tools with the use of developed rubrics only if they know the methodology of formative assessment and the methodology of e-learning.

*Activity A5. Demonstration of learning outcomes and reflection* involves evaluating the pedagogical potential of ICT tools for the following categories:

- A5.S1. Form of learning outcomes demonstration,
- A5.S2. Publication of results,
- A5.S3. Discussion of outcomes,
- A5.S4. Accumulation and export of educational outcomes.

Thus, developed rubrics help to obtain a more objective and reasoned evaluation of ICT tools used for the current formative assessment. The presented set of rubrics was used in elucidating the researcher's opinion about each tool according to the items used to compare different tools using "CSEM - Customer Satisfaction Evaluation Model".

Scoring rubrics are now being used by selected experts for the assessment of LMS or testing systems, which are installed and used at universities within the scope of their pilot verification. The expert group consists of LMS or testing system administrators, informatics or information technology teachers, who can train the users of the technologies during instruction, and experienced users of the systems. Apart from assessing the degree of fulfillment of the proposed system parameters (on a five-point scale), experts are also required to determine every parameter's degree of relevance from the point of view of the defined categories in all five activities, and – if needed – to suggest other suitable criteria to the set activities.

Members of the international work group assume the following to be the advantages of the executed, aggregated and analyzed expert assessments:

- Will enable the existing or future users to use the potential of the already operated LMS/TS (Learning Management System/Testing System) in a more effective manner,
- Will enable a responsible decision concerning the acquisition of new LMS/TS on the basis of a more objective assessment of their pros and cons in solving individual tasks in order for them to be fit for purpose,
- Will enable the designers of new or innovated LMS/TS to create their functionality in accordance with the current requirements for effective formative assessment at universities, which are represented by predefined parameters or parameters added by the experts,
- Will help validate the assessment tool itself for its general application in the university environment and other educational institutions.

## **CONCLUSION**

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The analyses of recent researches confirm that the potential of LMS/TS can be a factor in the transformation of practice of formative assessment at universities.

The main purpose of formative assessment is to support the needs of students and the educational system (study groups, educational institutions and the system as a whole) in its strategic intentions.

The use of LMS/TS for the purpose of effective and useful (for all the subjects) formative assessment must be based on theoretical concepts of formative assessment, which can be specific in its various approaches to learning, and on technological innovations in the ICT field.

The integration of both solutions into one prepared (by the authors of the study) evaluation tool in the form of scoring rubrics will enable the evaluation of the supply, quality and user-friendliness of the existing LMS/TS for the purpose of formative assessment and the identification of its pros and cons.

Internationally speaking, both users and manufacturers of LMS/TS can benefit from expert evaluation.

## **ACKNOWLEDGEMENT**

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The research leading to these results has received, within the framework of the IRNet project, funding from the People Program (Marie Curie Actions) of the European Union's Seventh Framework Program FP7/2007-2013/ under the REA grant agreement No: PIRSES-GA-2013-612536

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# Big Data EduCloud: New Educational Potential

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## Abstract

*The current rapid development in the field of BigData brings a new approach to teaching Database Systems. Reflecting the call for new knowledge and skills required from Graduates of the Faculty of Informatics and Management, University of Hradec Kralove, the topic of NoSQL databases, which are closely connected to BigData, was implemented in the curriculum. To ensure the quality of highly professional training program, the faculty started the co-operation with IBM in the summer semester 2015. The aim of the joint training program BigData EduCloud is to provide students with practical professional skills and prepare them for new positions that have recently been created on the labour market. The program consists of lectures, workshops and intensive consultations. Moreover, e-course in the LMS Blackboard was designed to support the study. Considering students' assessments, their performance in e-courses was tracked. Reflecting the results, the research problem was solved whether students' success rate in courses correlates to their visit rate, i.e. the frequency of their visit to the course. As expected, the significant correlation was discovered.*

## Keywords

*Big Data. E-learning. NoSQL. Hadoop. LMS. Efficiency. Success rate. Visit rate. Tracking.*

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## INTRODUCTION

In recent years, the term "Big Data" has become rather broad. Nevertheless, as with other frequently used terminology, the meaning is wide. There is no single definition, and various diverse and often contradictory approaches are available for sharing between academia, industry and the media. (Cech, Bures, 2004) One of them was proposed by Doug Laney in 2001. He introduced the new mainstream definition of big data as the three versus the big data: volume, velocity and variety (Laney, 2001). In some cases, two additional dimensions are considered: variability and complexity.

In the traditional database of authoritative definitions, the Oxford English Dictionary, the term of big data is defined as "extremely large data sets that may be analysed computationally to reveal patterns, trends, and associations, especially relating to human behaviour and interactions". (Oxford Dictionary)

The Gartner Company in the IT Glossary presents following definition: "Big data is high-volume, high-velocity and/or high-variety information assets that demand cost-

effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation”. (Gartner, 2016)

The widely quoted 2011 big data study by McKinsey defining big data as “datasets whose size is beyond the ability of typical database software tools to capture, store, manage, and analyse” (McKinsey, 2011).

‘Big Data’ means ‘Big Opportunity’. As described in figure 1, the phenomenal growth of cloud computing, mobile computing and social media has started an explosion in the volume of valuable business data. Social networks and many other cloud-based applications are not only increasing the amount of data, but also the types and sources of that data – both inside and outside the enterprise.



Figure 1: ‘Big Data’ means ‘Big Opportunity’ (WaLa! Platform, 2016)

For the purpose of this paper the term of ‘Big Data’ for large volumes of data that are difficult to process applying traditional data processing methods was used.

Every day the world produces 2.5 trillion bytes of data and the volumes have constantly been increasing. They can be imagined as outputs of sensors measuring the climate, data from social networks, pictures, videos, business transactions, unstructured text, and other formats.

Processing of large amounts of data, both structured and unstructured, in the traditional way means making huge investments in software and hardware implementations. Applying the Big Data technologies, data can be stored and analysed more efficiently and without large upfront investments. The companies understand the great potential in data analysis and their proper usage, on the other hand, the lack of qualified professionals who would be able to handle this data is a limitation to this process.

## **SUBJECT OF DATABASES IN CURRICULA AT THE FACULTY OF INFORMATICS AND MANAGEMENT**

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One of the main objectives of the Faculty of Informatics and Management, University of Hradec Králové (FIM, UHK) is to facilitate the integration of our students in national and

international labour markets by equipping them with the latest theoretical and applied investigation tools for the IT area.

Currently, databases have become an integral part of computer applications. Despite been invisible to the users; the applications cannot work without them. That is why students of the Computer Science study program are expected to be well prepared in this field. Most companies focusing on software development are expecting graduates to have both good theoretical knowledge and practical experience in this field. That is the reason why this competence is included in the curriculum and required from graduates at FIM.

The Database Systems courses were included in the curricula of bachelor and master study programs of Information Management and Applied Informatics more than 20 years ago. The model curriculum of ACM was applied. The ACM (Association for Computing Machinery) is the world's largest educational and scientific computing society delivering resources for advance computing as a science and a profession. A few years ago, the model was redesigned, currently providing two Database Systems courses on the bachelor level and one course on the master level. Currently, the explosive growth of database concepts has created the demand for including a new course on the master level which would reflect the latest developments.

In this respect, close co-operation with IBM Company appears to be a logical step using the EduCloud program. Its main objective is to create a transparent set of multidisciplinary courses, seminars and online practical exercises, which give students the opportunity to gain both theoretical knowledge and practical skills as well as to develop their key competences. Students participating in this program will get practical experience in a very specific field of great potential. The added value and one of the strong advantages of the program is the opportunity to receive globally recognized certifications credited by IBM for free.

Moreover, it is important to point out that the above-mentioned co-operation with IBM is the first of this kind in the Czech Republic and thus our students will be the first to be fully trained for the position of Big Data Analysts.

The IBM as the guarantor of the EduCloud program provides the FIM with the latest trends and knowledge required on the labour market, from the perspective of the commercial partner it proposes preparatory materials for the graduates, implements practice-oriented lectures and provides a software environment for running EduCloud workshops. IBM actively cooperates with the FIM on creating appropriate joint curriculum topics for the course of bachelor and master IT studies. The FIM is involved in selected areas of post-graduates training; it collaborates with IBM to create the appropriate courses and course modifications with respect to the content consistency within the EduCloud program.

The target group is represented mainly by the second- and third-year students of Applied Informatics and Information Management study programs. There are no special limitations which would prevent all students from applying for the EduCloud program.

## **THE BIG DATA EDUCLOUDS PROGRAM**

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The Big Data EduClouds program is structured into several modules. Some of them can be completed during the standard period of semester as accredited courses, the others were created solely for the purpose of this program. The FIM applies the European credit system which was integrated into this program.

As already mentioned, the program consists of single modules, faculty regular courses, additional seminars and on-line practical exercises. In order to meet the program requirements and get a final certificate of Big Data Analyst, a student should successfully pass all regular faculty courses listed in the curriculum as well as all IBM modules. The price of this certificate is thanks to the IBM sponsorship reduced from \$ 200 to \$ 30, which is a strong motivating tool for the students. They may also be certified in DB2 Fundamentals (Chong et al., 2014) focusing on the position of administrator or developer. Those who do not wish to complete the entire course have the opportunity to attend individual modules they are interested in but without the possibility to obtain the Big Data Analyst certificate. During the program, students can also get certification in DB2 Academic Associate, which is free and it can be achieved after completing the faculty courses Database systems (A\_DBS1), Database systems 2 (A\_DBS2) and lectures Hadoop (L.HAD) and NoSQL-Introduction (L.NoSQLDB).

New courses have also been awarded by credits, the overview of which can be seen in Table 1. As part of the A.DBS1 module requirements student's task is to create a realistic project, whereas within A.DBS2 module students have to attend a mandatory workshop DB2, verify their knowledge by completing the e-test and create a real project. The Lecture L.HAD aims at information about Big Data, explains the history and creation of Hadoop, highlights current trends and prepares students for the e-learning test. Following voluntary lecture L.NoSQLDB deal with detailed introduction to NoSQL database types and their use in practice; acquired knowledge was examined by the e-test. In the first academic year, students can obtain a certificate DB2 Academic Associate.

Another part of the program is implemented in the second academic year, when L.BigIn is introduced with the specifications of Hadoop use in the enterprise environment. Students learn about the platform, the NoSQL database types and their use in practice. As in previous year, students' knowledge and skills are assessed by the e-test designed by the team of university teachers and IBM specialists.

The E.BigIn module aims at the IBS online technology with prepared scenarios of real data. Students receive the IBM Voucher, which entitles them to access directly the IBM environment, and the platform containing exercises and subtasks.

Within the L.SPSS the real demonstration is performed on the use of selected statistical methods for data processing. The E.SPSS and E.BigIn / SPSS modules deal with IBM technology and selected scenarios of real data. As in previous modules students receive the IBM Voucher allowing them to directly access the environment and the platform where IBM experts train students who are expected to perform particular subtasks. At the end of the program, students are awarded the Big Data Analyst certificate, as described above. For easier reference see Table 1 that streamlines program modules in the time sequence.

In the course of the program, students can reach two certifications, which brings them obvious advantages. First, they can get the IBM certificates as part of their CV documents, and second, the certificates entitle them to a better starting position in IBM, be it an internship or full-time positions in the company.

Table 1. Curriculum of the EduCloud modules

Module Abbreviation	Subject	Type of Module	Timing	Credits
<b>A.DBS1</b>	Database systems	University accredited	WS	6
<b>A.DBS2</b>	Database systems	University accredited	SS	5
<b>L.HAD</b>	Hadoop	Lectured by the IBM	SS	1
<b>L.NoSQLDB</b>	NoSQL	Lectured by the IBM	SS	1
<b>A.DORDB</b>	DOR database	University accredited	WS	6
<b>L.BigIn</b>	Lecture Big Sheets	Technological lecture	WS	2
<b>E.BigIn</b>	PoT BigSheets	EduCloud online	WS	
<b>A.APSTA</b>	Applied Statistics	University accredited	WS	6
<b>L.SPSS</b>	SPSS Modeler	Lectured by the IBM	WS	2
<b>E.SPSS</b>	PoT SPSS Modeler	EduCloud online	WS	
<b>E.BigIn/SPSS</b>	PoT SPSS Modeler	EduCloud online	WS	2

*Note: WS=Winter semester, SS=Summer semester*

## E-LEARNING IN THE EDUCLOUD PROGRAM

The whole program is supported by e-learning lessons. All the study materials are created and uploaded in the FIM LMS BlackBoard (Bradford, 2007), (Stepanek, Simkova, 2013), (Poulova, Simonova, Manenova, 2015).

All students as well as teachers and IBM experts have access to the e-learning course which was designed to give relevant and essential information about the program process. The e-learning courses (modules) were based on the close co-operation between parties, university teachers and IBM experts, so the connection between academic theory and practical real life aspects are perfectly in accord here. (Cerna, Poulova, 2012), (Poulova, Simonova, 2012), (Tomaskova, Nemcova, Simkova, 2011), (Zentel et al., 2004)

In this particular case, new practices and strategies that have emerged precisely from direct co-operation with IBM have been used. The basic idea came from the conception of the Big Data, which is currently a very frequently dealt issue, not only attracting the interest of students and teachers, but also creating a need for some new aspects in subsequent e-learning environment. (Kotzian, Konecny, Krejcar, 2011), (Komarkova, Hub, Sedlak, 2014)

Each module in the e-learning course is equipped with its own guiding (didactic) instructions, study materials and modified tests with comprehensive sets of questions.

Study materials have been developed not only as standard presentations; they contain audio-visual materials, animations and video instructions. Students' attendance in the courses and lectures is monitored in order to evaluate not only the results of the individual tests but also to detect the fields of students' interest.



## THE PILOT PROGRAM RESULTS

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Student's progress in the course during the first academic year of the pilot BigData EduCloud program was tracked and analysed with special focus on students' reported activities in the program. The results, which appear to be very interesting, will be applied and used for further development of the program in order to increase the quality and consistency of teaching and learning environment in the upcoming semester (see Table 1).

Table 2 indicates an overview which shows high interest of FIM students in the pilot program:

- 54 % of students in the second year of the Information management and Applied Informatics study programs participated in the program;
- out of these, 43 % successfully passed the achievement tests and examinations (57 % failed).

Table 2. Basic program overview in numbers

Total number of students participating in the program:	<b>54</b>
Total number of successful students ( <i>students who have successfully completed modules: A.DBS1, A.DBS2, L.HAD, L.NoSQLDB</i> ):	<b>23</b>
Total number of failed students:	<b>31</b>
Total number of students applying for the certification:	<b>21</b>
Successful students:	<b>13</b>
Failed students:	<b>8</b>
The number of DBS2 students in summer semester2014/2015	<b>100</b>

In total, 54 % of students from primary focus group participated in the BigData EduCloud program. Total number of successful students in percentage is 42.60 %, whereas 57.4 % of the participating students failed. Totally 61.90 % of participating students was successfully certified (38.1 % did not succeed). The failure rate is rather high. However, this activity does not belong to compulsory subjects and the topic (subject) is demanding (from the time and knowledge), the 2/5 success rate is not low.

## SUCCESS RATE IN THE SUBJECT VERSUS VISIT RATE TO THE COURSE

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Below, data collected from tracking students' performance in the course are presented. The research question is whether there exists any correlation between student's success in the course, i.e. meeting the requirements and passing the course, and the frequency of their visits to the course. In other words, are students more successful, if they more frequently access the course? Does the learner's low frequency of visits to the course correlate to poor study results, i.e. failing the course?

As all modules are supported by e-courses in LMS Blackboard, it was interesting and easy to observe learners performance in the course.

The research was conducted in e-course Database Systems 2 where the methodological guide was available to students, study materials, assignments settings, tests, communication tools etc. Totally 122 students enrolled in this subject; 86 of them successfully passed the course. Complete evaluation reflecting the ECTS (European

Transfer Credit Systems) is displayed in figure 2. Average assessment follows this scale: A – excellent, B – very good, C – good, D – satisfactory, E – sufficient, F – failed.

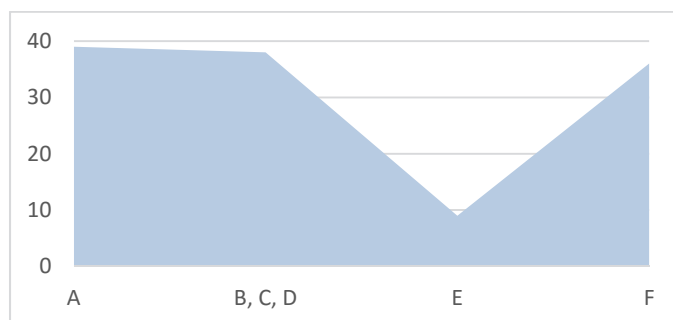


Figure 2: Students assessment after the course (n)

The visit rate of the DS2 course oscillated from zero to 346; the average visit frequency was 93.53; median 90. These data show that (in average) students accessed the course, which was taught for 13 weeks, once per day, which demonstrates rather intensive use. Reflecting the size of the research sample, advanced statistical methods were not used. Answer to the question whether there is any correlation between learner's success rate (i.e. passing the course) and the visit rate (i.e. frequency of visits to the course) is displayed in figure 3 and table 3.

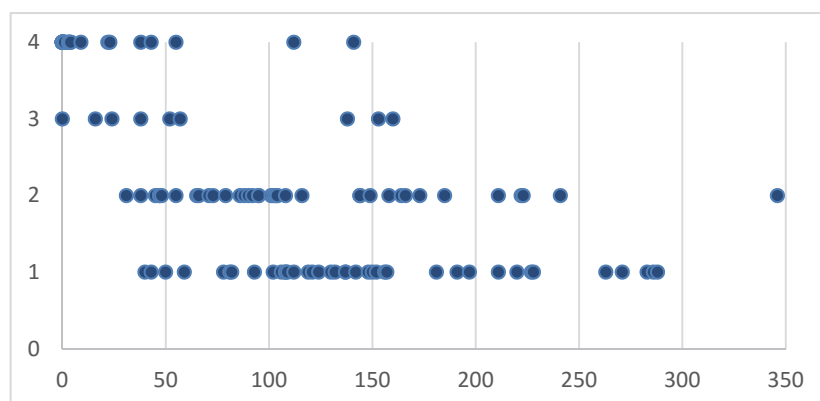


Figure 3: Correlation between the success rate and visit rate to the e-courses.

Table 3. Correlation between the success rate and visit rate to the e-courses.

	A	B, C, D	E	F
mean	149.3	122.1	63.8	12.9
min	40	31	0	0
max	288	346	160	141
median	137	102	45	0.5

The received results prove the certain correlation was detected: whereas students having A (Excellent) accessed the e-course 149x in average, the unsuccessful students who failed (F) reached significantly lower frequency – their average visit rate was 13x. Similarly to this, the identical correlation was detected in medians.

The conclusion is the statistically correlations were discovered in relation of students' success (passing the e-course) and the frequency of the visit rate to the course.

## **CONCLUSION**

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Fast development of latest technologies is reflected in new requirements for graduates' knowledge and skills. This was the main reason, why the co-operation started between the Faculty of Informatics and Management, University of Hradec Kralove (FIM UHK), and IBM Company. In the data analysis and their proper usage, the IT companies see a great potential. What they are concerned about, however, is the lack of qualified professionals who would be able to handle this data. Recently the positions of Big Data architects, Big Data analytics, and lead engineer for Big Data have been requested and offered by plenty of IT companies on the labour market. This university program prepares students for key and demanded positions. Consequently, this was the main reason why the FIM curricula were adjusted to latest requirements.

The co-operation and particularly the new subjects resulting from, are presented in the first part of the paper. The tracking of students' performance led us to the question on the process of learning in the e-courses, which enhanced the instruction. The discovered correlation between the students' success rate in studying the new subjects and their frequency of visits to the course showed that the tutor's guidance in the e-course could be improved. This will be the target we are going to focus in the future.

New requirements for graduates' knowledge and skills was the reason why the Faculty of Informatics and Management, University of Hradec Kralove, developed the co-operation both with IBM and local IT companies within the HIT Cluster. The IT companies see a great potential in curricula which reflect requirements of graduates' potential employers. However, the assessment of curricula is a long time and demanding process so the FIM strongly appreciates the efforts the HIT Cluster companies devoted to this process. Reflecting the expert recommendations, large changes were made so as the graduates were well prepared and succeeded on the labour market.

## **ACKNOWLEDGEMENT**

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The paper is supported by the SPEV project FIM UHK.

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# Personal Learning Environment in Higher Education

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## Abstract

*The article analyzes a prospective concept of personal learning environment within academic environment. The analysis is mostly of theoretical nature, revealing the essence, structure, functions and application of the idea in modern education. The theoretical background of personal learning environment centers around the concepts of self-regulated learning, connectivism and constructivism. Structuring personal learning environment theoretically can be beneficial for a deeper insight into the elements and motivation behind the use of the idea. The article presents shortly some of the practical applications of personal learning environment, namely the software kits for organizing user interface. Besides, the paper discusses current opposition between the concept and more institutionalized learning systems, the learning management systems (LMSs). The review is tuned to current tasks within European project IRNet – “International Research Network for study and development of new tools and methods for advanced pedagogical science in the field of ICT instruments, e-learning and intercultural competences”. It is stressed that professors should become facilitators and should guide their students in their self-motivated learning path.*

## Keywords

*Personal learning environment. Higher education. ICT tools. Modelling personal learning environment. Teachers’ and students’ ICT competences.*

## INTRODUCTION

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Current generation of young learners, born in the 1980’s and the beginning of the 1990’s, the so-called ‘net generation’ gain ICT-competences quite easily (Valtonen et al., 2012). This net generation, or the so-called generation Y grew up with the progress of digital technology and these learners got used to enormous fields of information, besides, they are getting to newer and newer tools for obtaining knowledge. This represents a huge challenge for the educational systems that are on the way of changing dramatically. At the same time, these learners face enormous challenge in their future profession, as they will need to present even newer ICT competences in the job market on graduation. These new learners force teachers to switch to digital learning environment too. Specifically, this new generation of motivated learners is struggling in this vast field of tools for learning.

Current interest in self-motivated learning has given birth to quite a number of terms that signify the unique collection of certain web-based instruments helping the learners to

organize their knowledge activities, varying from PLE (personal learning environment), PLN (personalized learning network), VLN (virtual learning environment), PLL (personal learning landscape) to ILE (informal learning environment). Of all these the term PLE has probably been chosen by the majority as the most appropriate.

PLE is a relatively new concept, the history of the terms PLN or PLE, obviously quite similar in meaning, starts as far back as 1998/99 (PLE diagrams).

Related terms such as web 2.0 have led to still newer potential terms e-learning 2.0, pedagogy 2.0, student 2.0, faculty 2.0, and classroom 2.0, with the suffix 2.0 characterizing themes such as openness, leaving a little room for learners to manage and maintain a learning personalization, collaboration, social networking, social presence, space that facilitates their own learning activities as well as user-generated content, the people's Web, and collective wisdom (Dabbagh and Kitsantas, 2012).

The goal of this paper is to research into the essence of personal learning environment, aided by electronic means, to outline briefly its structure, approaches and practical applications for teaching practice.

All the above mentioned problems are the focus of research within the European research project IRNet –“International Research Network for study and development of new tools and methods for advanced pedagogical science in the field of ICT instruments, e-learning and intercultural competences”, where we are honoured to participate (Kommers et al., 2015; Noskova et al., 2016).

## **METHODS**

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The research was conducted by the methods of the literature review analysis, which included an overview of recent publications, including web-based ones.

## **THEORETICAL BACKGROUND OF PLE**

PLEs are typically described as a collection of different ICT tools and software, usually social software, to foster self-regulated and collaborative learning (Valtonen et al., 2012). Mott defines PLEs as student-created matrices of resources that they themselves select and organize, thus he stresses students' self-regulating role (Mott, 2010).

Stephen Downes describes a PLE as: "... one node in a web of content, connected to other nodes and content creation services used by other students. It becomes, not an institutional or corporate application, but a personal learning center, where content is reused and remixed according to the student's own needs and interests. It becomes, indeed, not a single application, but a collection of interoperating applications – an environment rather than a system" (Downes, 2015). PLEs can be considered a technology and a pedagogical approach which is developed by the learner, but it also can be considered a learning approach (Dabbagh et al., 2012)

PLEs is a quite modern and ambitious idea but there doesn't exist a single picture presenting their functions and purposes.

Considering PLE more of a pedagogical approach, on the base of questionnaire for university students of different courses Valtonen et al. (Valtonen et al., 2012) have drafted the list of functions and purposes of PLEs as they are seen by the students:

- mirroring a conventional learning environment;
- an environment for reflection;
- an environment to showcase skills;
- an environment for collaboration and networking.

More on the functions was stressed here (Rahimi et al., 2014b): PLEs serve for creative and collective contribution, knowledge (co-producing, communication, knowledge management and organizing, self-expressing, creating and managing personal pages, analysing and developing new concepts and ideas, and sharing and exchanging documents.

The construction of PLEs grounds on a few scientific trends: personalized or self-regulated learning, connectivism, collaborative learning and constructivism.

The idea of PLEs has strong similarities and most likely derives from the idea of personalized learning (Zimmerman, 1990) and a later concept of connectivism supported by two main publications “Connectivism: a Learning Theory for the Digital Age” (Siemens, 2004) and “An Introduction to Connective knowledge” (Downes, 2007).

Personalization is a trending topic in educational technology. The definition is so broad as to become a catch phrase to describe many new tools and transformation initiatives (Dexler, 2014).

Self-regulated learning theories of academic achievement are distinctive from other accounts of learning and instruction by their emphasis a) on how students select, organize, or create advantageous learning environments for themselves and b) on how they plan and control the form and amount of their own instruction. Still, Zimmerman stresses, that students who lack self-management skills will seek advice from their educator (Zimmerman, 1990).

G.Siemens quite sensibly states that former educational theories, mainly behaviorism, cognitivism, and constructivism were overshadowed by a new one – the connectivist theory, due to profound changes brought in by new technologies.

Principles of connectivism are well known:

- learning and knowledge rests in diversity of opinions;
- learning is a process of connecting specialized nodes or information sources;
- learning may reside in non-human appliances;
- capacity to know more is more critical than what is currently known;
- nurturing and maintaining connections is needed to facilitate continual learning;
- ability to see connections between fields, ideas, and concepts is a core skill;
- currency (accurate, up-to-date knowledge) is the intent of all connectivist learning activities;
- decision-making is itself a learning process. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality.



While there is a right answer now, it may be wrong tomorrow due to alterations in the information climate affecting the decision.

Connectivism is the thesis that knowledge is distributed across a network of connections, and therefore that learning consists of the ability to contrast and traverse those networks. ...there is no real concept of transferring knowledge, making knowledge or building knowledge. Rather, the activities we undertake when we conduct practices in order to learn are like growing and developing ourselves and our society in certain (connected) ways (Downes, 2012).

One example of connected knowledge are social networks like Twitter, Facebook, Pinterest and LinkedIn which can be used for self-motivated learning, and this is proved by the fact that they are currently in the top 20 tools on Jane Hart's list of top 100 tools for learning, only followed by Moodle as the first LMS on that list.

Aside from self-regulated learning and connectivism, the ideals and assumptions concerning PLEs align with the theory of collaborative learning. Collaborative learning refers to interactions between people that are expected to trigger mechanisms for learning (Dillenbourg, 1999). This interaction can be viewed as the one, taking place in social media, as they facilitate the creation of PLEs that help learners aggregate and share the results of learning achievements, participate in collective knowledge generation, and manage their own meaning making (Dabbagh and Kitsantas, 2012).

It should be noted that collaborative learning (working together for the same task) is not the same as cooperative learning which is working for different tasks but depending upon the success of the other group.

Constructivism serves as yet another theoretical framework for student construction of personal learning environments. Students are expected to access, navigate, disseminate, and synthesize large quantities of information for the purpose of constructing knowledge (Dexler, 2014).

## **THEORETICAL BACKGROUND AND PRACTICAL DEVELOPMENTS IN STRUCTURING PLES**

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If we get back to the definition of PLEs as "a collection of different ICT tools and software", "student-created matrices of resources" or "one node in a web of content", we will suspect that inner composition of PLEs can be quite intricate.

Modelling the structure of PLE has been a subject of previous research. Quite inspiring collection of PLE models is suggested here (PLE Diagrams). Some of the models underline the person-based aspect of these diagrams, as some of the professors indicate in the center either their name, or a generalized name of the person in certain linguistic community, or the pronoun ME, which is highly notable from the cognitive-linguistic point of view. This again confirms the aspect of personalization behind the research into PLEs. Quite often these diagrams are supplied with a picture or photo of the person. This reveals the key feature of a PLE - the learner develops an online identity where the personalized learning environment provides cues, that prompt the learner about what to share, what not to share, who they chose to share with, and how to effectively merge formal and informal learning (Dabbagh and Kitsantas, 2012).

This collection of models gives a good idea of two main trends in presenting PLE structure. One could be called instrument-based, or technology-based and the function-, or motivation-based structure. The first type of the models have specific titles of tools as its core nodes, like, Skype, Google Docs or Facebook, while function-based ones' present motivation or function of the tools the learner uses, for instance, the typical nodes would be: sharing, collaborating, presenting, searching etc. This last type of models is particularly useful for pedagogy.

Quite an interesting motivation-driven model of building PLE was developed by Rahimi et al. (2014a). They defined three dimensions to enhance student's control over educational process: capability (refers to the cognitive abilities and competencies student requires to participate in particular learning experiences), support (refers to the resources such as learning materials, course structure, teacher's guides and scaffoldings, and community experts that the student needs in order to carry out their learning), and autonomy (refers to the student's freedom and ability to choose what, how, when, and where to learn).

Quite similar in the approach is Dexler's model, who developed a networked student model focusing on the learning process rather than the specific tools used to build a PLE. Technology tools are helpful as examples, but are only important in how they support the following processes:

- practicing digital literacy;
- practicing digital responsibility;
- organizing content;
- collaborating and socializing;
- synthesizing and creating (Dexler, 2014).

And as long as they are personalized they are sometimes called ephemeral, because they are hard to track and see. Many more questions should be answered, of theoretical and practical nature, for example, what should the interface between teacher and student be like? (Valtonen, 2012), if at all. How do teachers evaluate students' self-driven learning, if they should? What should the student's report on independent work look like?

From theoretical modeling let us turn to practical applications of the very idea of PLE. There are software kits (functionality mash-ups) that help to organize learning materials or resources in a single computer interface: Evernote, Symbaloo (Symbaloo EDU), iGoogle, Netvibes, PageFlakes, Diigo to name just a few. They are combinations of web tools that bring together multiple applications as well as content from various sources with a user-friendly interface. Users can make their daily learning path easier to follow, based on user preference.

Part of these tools are mainly for archiving, notetaking and bookmarking. Let's have a quick look. Evernote is a closed source freemium suite of software and services, designed for notetaking and archiving. A "note" can be a piece of formatted text, a full webpage or webpage excerpt, a photograph, a voice memo, or a handwritten "ink" note. Notes can also have file attachments. Notes can be sorted into folders, then tagged, annotated, edited, given comments, searched, and exported as part of a notebook.

SymbolooEDU is simple start page that allows you to store and share all of your favorite bookmarks and resources visually. Learners can organize websites, Google Docs, videos, lesson plans, and even more.

Diigo is a social bookmarking website which allows signed-up users to bookmark and tag web-pages. Additionally, it allows users to highlight any part of a webpage and attach sticky notes to specific highlights or to a whole page. These annotations can be kept private, shared with a group within Diigo or a special link forwarded to someone else. The name "Diigo" is an acronym from "Digest of Internet Information, Groups and Other stuff".

What is crucial in these recent developments for the teaching staff is that students do not have innate skills to manage these interfaces and the teacher should help them, facilitate their learning, guide the students in organizing their independent learning process (Noskova and Pavlova, 2011). It is the goal of personal learning to empower the student to independently construct rich, effective networks in support of his or her learning objectives (Dexler, 2014).

We are totally accepting this opinion, because, presumably, professors have already gone through all these steps and their PLEs are much more detailed, specific and better-organized.

## **PLE OPPOSED TO LMS**

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In the situation when personalization of education is gaining more momentum, the ongoing scientific debate on the clash between LMSs and PLEs gets more acute. Apparently, an LMS will suit a constructivist approach to learning whereby content is organized, learning is structured, sequential, placed within context, managed etc. Whereas a PLE/PLN tool structure reproduces the connectivist approach of knowledge as "a pattern of relatedness" (Siemens) which is "embedded in a mesh of connections" (Downes).

It is quite bravely suggested that PLEs are the next step in the development of educational technology, a replacement for learning management systems (LMS), providing tools and learning practices to meet the needs of the knowledge society (Valtonen et al., 2012).

PLEs seem to be more effective in terms of personalization and learner control over the process, which institutionalized LMSs most often lack (Dabbagh and Kitsantas, 2012), though it should be mentioned that with the modern concept of adaptive LMSs there is some technical possibility to adjust the learning system to students' personal needs (Kostolányová, 2012), where the students will be prompted to set their own learning goals (Drlík et al., 2014), manage content and their learning process itself (Morze and Kocharyan, 2014).

In quite an insightful paper Mott (2010) presents a comparison of strengths and weaknesses for LMSs versus PLEs. Among other differences, it is stressed that LMSs are teacher, rather than student, centric, while PLEs are student-centric (each student selects and uses the tools that make sense for their particular needs and circumstances).

Noskova stresses, that the switch from LMSs to non-linear, flexible personalized learning environments could improve the quality of education, but the teacher will have to gain new professional competences, to be able to communicate in the new field. For

instance, the new teacher's skills could include communicating in groups and organizing group work. In general, the organization of this web-based educational communication is a much larger task than just delivering to students learning content (Noskova and Pavlova, 2011).

Sadly, a recent survey into ICT use in European schools revealed that teachers mostly use ICT in classroom for preparing classes, while the use of ICT for learning is lagging far behind (Sekret and Kommers). Among other barriers to more profound use of ICTs in schools there were revealed the following: there is a lack of teacher training courses, besides, there is a lack of integration between ICT use in teaching and learning.

Evidently, ICT competences, or digital literacy is necessary to become an effective networked learner. Consequently, the teacher's digital literacy should reach far beyond the student's one. Digital literacy extends beyond a basic comfort with new technologies (Alkali and Amachi-Hamburger, 2004), there can be different approaches to its structure. For instance, Dexler identifies five major digital skills: photo-visual (the ability to make sense of graphical representations), reproduction (create new artifacts from existing content), branching (knowledge construction from hypertext), information (evaluating content), and socio-emotional (interacting effectively with others online) (Dexler, 2014).

Even more experience and skills are needed for what can be an integration of both learning approaches – the PLE and the LMS one. Mott stresses that knowledge-dissemination technologies (LMSs) and community-building tools (PLEs) can be integrated for better performance within the learning process into an Open Learning Network (OLN), developed and deployed by the Brigham Young University. The OLN combines existing institutional applications, web-based tools, applications, content stores, and facilitating "connective tissue" technologies that allow them all to function together seamlessly (Mott, 2010).

Quite obviously, the prospects of PLEs, and more recently, of integrated learning environments are abound with learning opportunities, but it leaves many issues to be addressed.

## CONCLUSIONS

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With the current trends of personalization of education, complicated by current technological progress and induced by the pressuring need to improve the quality of education the professor's role is no longer limited to delivering course content. It extends as far as guiding the student and facilitating him in his self-driven learning advance.

Students' self-propelled learning should be guided by the teachers, not otherwise, thus professors should be getting specific updates on newer, more efficient tools to organize their students' PLEs, and on a regular basis.

It might seem quite evident that the core tools for independent learning are similar for the students of different courses, while later they can get more specified. This leads to a growing need to model the students' starting PLEs, and this should become a continuous process due to ongoing technological developments in ICTs. With the students' progress in their study, the models will be adjusted according to their course and individual needs. It

still remains to be researched how this self-initiated learning should be evaluated, and if it should, what the interface of this evaluation can be.

## ACKNOWLEDGEMENT

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The research leading to these results has received, within the framework of the IRNet project, funding from the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Programme FP7/2007-2013/ under REA grant agreement No: PIRSES-GA-2013-612536.

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# Recommended Applications for Making Presentations and Didactic Videos. Some Research Results

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## Abstract

*The article describes the preliminary results of the implementation of WorkPackage 4 (WP4) "Selection and testing new ICT tools" in the framework of the international research network IRNe, represented by researchers from partner institutions in Poland, Slovakia, Ukraine, Australia. These results concern the analysis and study of some categories of ICT-tools for making multimedia presentations and didactic videos. All the package period has been divided into 5 main stages. Authors presented a ranking list based on quality and quantity assessment of chosen ICT-tools and proposed some recommendations of features for good presentation and didactic video as well as specified typical mistakes of designers and users.*

## Keywords

*Applications. Presentations. Didactic video. International research network. Assessment.*



## INTRODUCTION

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A multimedia presentation can play an important role in teaching, being a perfect tool supporting the process of teaching and learning, combining all media in one application.

One research (Mayer 2001: 149-150) looked into some learning preferences and hypothesized that different people learn in different ways, so it is best to present materials in different formats. By using multiple presentation formats, instructors (teachers) can accommodate each student's preferred learning style.

The most effective computer-based *Multimedia* presentation is a concise narrated animation (CNA) (Mayer 2001: 191) which the author defines as a concise narration describing the cause-and-effect system coordinated with a concise animation depicting the cause-and-effect system.

*Multimedia* - Include corresponding animation and narration rather than the narration alone;

*Integrated* - Corresponding animation and narration presented simultaneously rather than successively;

*Concise* - Extraneous words, pictures, and sounds are excluded rather than included;

*Channeled* - Word presented as a speech rather than on-screen text (or both speech and on-screen text);

*Structured* - Include series of narrated animation comments describing key steps in the process (for cause-and-effect material).

The offer of software for creating multimedia presentations is broad, but those preparing for the teaching profession are rarely familiar with niche programs. It is an alarming consistency in the context of the need to find ways of effective presentation, i.e. the ones that will attract attention, motivate to learn and constitute a source of information. Currently, the following features of effective presentations are emphasized (Brosch, Frania 2014:30):

- *Multiplicity of media* - presentation should contain at least one static element, i.e. text, photos, graphics, and at least one dynamic component, such as video, audio or animation;
- *Nonlinearity* - the user is able to "jump" from one item to another without losing the sense of the presentation;
- *Interactivity* - which is based on the recipients' decision of what and how they want to see or read, and this is related to content requirement and form management;
- *Coherence* - all elements of the presentation should form a coherent whole with no possibility of exerting control separately on its different parts;
- *Digital mode* of inputting and outputting content (Parekh, 2006:2-5).

## WORK PACKAGE 4: BASIC OBJECTIVES.

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Among more important Objectives of WP4 there are:

- To select and test new IT tools: social media, selected Web 2.0 and Web 3.0. Massive Open Online Courses, etc; to evaluate synchronous and asynchronous tools, methodologies and good practices; to compare and evaluate, LMS (*learning management systems*), CMS (*Contents Management Systems*), VSCR (*Virtual synchronous classrooms*), SSA (*Screen Share Applications*), CSA (*Contents Sharing Application*), cloud computing environment;
- To identify and define profiles of *virtual campus*, *virtual learning environment* and *virtual synchronous classroom*; to review and compare virtual classrooms (VCR) based on hardware equipment against the ones based on PCs; to identify VCRs which are better aligned with the teacher's or student's activities; compare from the technological point of view the best known VCR (PC based) available on the market; to analyse the technological profile that virtual classrooms should have to ensure good pedagogic results;
- To characterize methodological and technological aspects of multimodal didactic communication;
- To identify general methodological aspects of VCR with a special focus on online tutoring, continuous online evaluation and good practices; to test ICT tools concerning effective developing ICT and e-learning competences as well as in design of intercultural competences.

## METHODOLOGY AND STAGES OF RESEARCH

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According to the road map the whole period of implementation of this WP was divided into 5 main stages.

Step 1 includes:

- Identifying necessary skills to teach in the school of the future, according to previous studies made and available documents;
- Absolutely necessary skill:
  - Know how to present contents in multimedia format (presentations and didactic videos).

Consequently, different ICT-tools were analysed, their application in education was studied and a different category of application was specified, in particular Module 001, which contains:

- Tools for making presentations.
- Tools for making didactic videos.

Step 2 includes: Tools identified by the team are expected to be reported in a Google Drive document available for remote collaborative work. The research teams responsible for identifying tools should present items to be used as criteria to evaluate and compare Tools by each task using a CSEM (Custom Satisfaction Evaluation Model).

Step 3 involves comparing and concluding on the relative importance of tools, using a CSEM.

Step 4 needs statistic treatment of survey results and final conclusions.

Step 5 covers web-based round table “Recommended and selected IT tools for different teaching methods and processes”, where conclusions are presented.

## **GENERAL BACKGROUND OF RESEARCH**

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### **The review of definitions behind the notion of a presentation**

The researchers of the IRNet consortium from University of Silesia (Poland – the Coordinator), Constantine the Philosopher University (Slovakia), Borys Grinchenko Kyiv University (Ukraine), Dniprodzerzhinsk State Technical University (Ukraine), Curtin University (Australia), The Graal Institute (Portugal) analysed a different definition of what a presentation is. For example:

“Presentation is the practice of showing and explaining the content of a topic to an audience or learner” (Cf. Merriam-Webster online <http://www.merriam-webster.com/dictionary/presentation>).

Depending on the sense in the context and meaning: “The giving of something to someone, especially as part of a formal ceremony; The manner or style in which something is given, offered or displayed; A formal introduction of someone, especially at court. The action or right of formally proposing a candidate for a Church benefice or other position; A speech or talk in which a new product, idea, or piece of work is shown and explained to an audience; Medicine: The position of a fetus in relation to the cervix at the time of delivery” (<http://www.oxforddictionaries.com/definition/english/presentation?q=presentations>).

In fact, there is a need to continuously transmit significant amounts of complex information in all sectors of economy and education.

This was done through numerous lectures, meetings and presentations where due to the nature of the data transmitted the illustration and visualization were in the form of different separate media. Lectures, presentations before 2000 were conducted with the help of a large number of different media tools: Maps, charts, tables, boards, films, sound, recordings, photographs.

The presentation of all these elements traditionally required a whole range of teaching aids, starting from a blackboard and chalk, through very laborious preparation of charts and slides, to some sophisticated audio-video systems.

### **Research tools and procedures**

Experts of the IRNet consortium from Poland, Slovakia, Ukraine and Portugal conducted the analysis and discussion concerning more important activities of Tools for Making presentations.

## **Data Analysis**

During the discussion and analysis of previous experience there was elaborated a list of tools, whose applicability and relative importance for making presentations had to be measured according to 1-5 system, there was also prepared a ranking list of ICT-tools for making presentations and didactic videos. Below presented are the most important items to define quality of suggested tools for making presentations and didactic video. The ranking graph elaborated total points, summing the assessment given by all the research groups (Figure 1, Figure 2):

1. Can slides have standard format/templates?
2. Can background be pre-defined to the slides?
3. Can images be inserted in the slides?
4. Is there an image editor?
5. Classify image editor (1-10 points).
6. Is it possible to format colours?
7. Is it possible to compress imaging?
8. Is it possible to remove background?
9. Is it possible to insert or crop images?
10. Can a photo album be inserted automatically in a slide show
11. Is it possible to insert a standard form?
12. Is it possible to insert graphics?
13. Is it possible to insert hyperlinks?
14. Is it possible to insert audio files?
15. Is it possible to insert videos?
16. Is it possible to insert different slide transitions?
17. Is it possible to insert different types of animations?
18. Is it possible to record audio narration?
19. Is it possible to set the time of presentation for each slide?
20. Is it possible for the author to make notes for the presentation?
21. Can a presentation be automatically converted into a video?
22. Can a presentation be automatically saved in PDF format?
23. Can a presentation be automatically saved as image?
24. Are there interactive options (interactive buttons)?
25. Is it free or commercial?
26. Are there automatic sharing options (in social networks or elsewhere).

After a comprehensive analysis more than 20 tools for making presentations were presented. Among them only five most effective tools were identified according to the results of CSEM analysis. The main tools are the following:

- MS Power Point
- Prezi

- Impress LibreOffice
- SlideDog
- ClearSlide/SlideRocket

Additional tools:

- Powtoon
- IBM Lotus Symphony
- Wondershare DVD Slideshow Builder Deluxe
- Corel Presentations
- Lotus Freelance Graphics
- Harward Graphics
- Grapher
- Slidewrite Plus
- other.

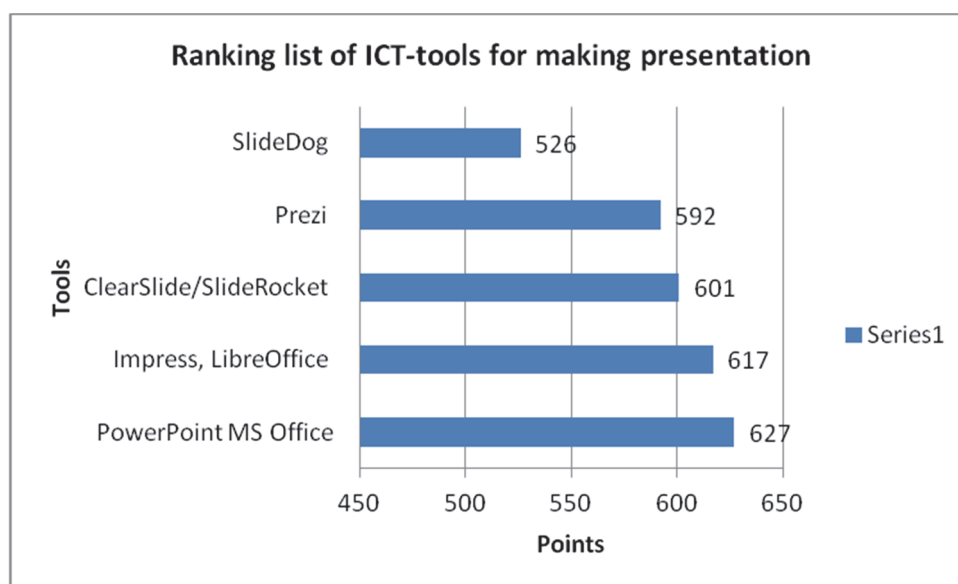


Figure 1: Ranking list of ICT-tools for making presentations

On the basis of a study and research (Brosch, Frania 2014) we can conclude that students often make a lot of mistakes during elaboration of a multimedia presentation, namely:

- excessive effects;
- incorrect choice of fonts;
- too long text;
- repetition of the same effects;
- excessive array of colours;
- authors (students or teachers) often prefer elaborating presentations in the form of a slide-show or presentation with linear structure;

- disproportionate (not clear or too small graphical) objects.

The IRNet researchers, basing on previous study conducted by other experts elaborated several rules of the best use of PowerPoint (Figure 2):

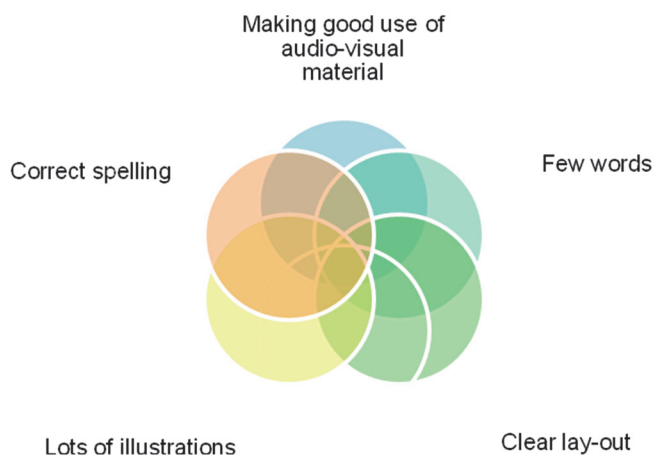


Figure 2: Basic requirements for good presentation (Source: Own research based on (Toon Goedemé))

We should keep in mind that while designing a presentation it is necessary to take into account some important rubrics, such as: Research and Note Taking, Pre- Production Planning – Storyboard, Introduction, Content, Text, Layout, Citations, Graphics, Sound and/or Animation, Writing Mechanics (PowerPoint Rubric, <https://www2.uwstout.edu/content/profdev/rubrics/pptrubric.html>)

## Didactic video

Experts of the IRNet consortium from University of Silesia (Poland, the coordinator), Constantine the Philosopher University (Slovakia), Borys Grinchenko Kyiv University (Ukraine), Dniprodzerzhinsk State Technical University (Ukraine), Curtin University (Australia) conducted analysis and discussion concerning very important aspects and tools for making didactic video.

During discussion and analyzing previous experience the group developed a list of criteria to range the suggested tools for creating didactic videos and they have also ranked the chosen ICT-tools in a list.

A list of criteria to define quality of suggested tools for making didactic videos is presented below:

1. usefulness;
2. educational potential;
3. multifunctionality;
4. survey options;
5. friendly interface;
6. free;

7. group collaboration work support, webinar support;
8. podcast support;
9. tools for scheme and graph creation;
10. multi-windows interface;
11. customization and editing of content on both Mac and Windows platforms.

After a comprehensive analysis of multiple Tools for Making didactic videos there were identified several Main most effective tools. Among **main** and **additional** tools there are (Figure 3):

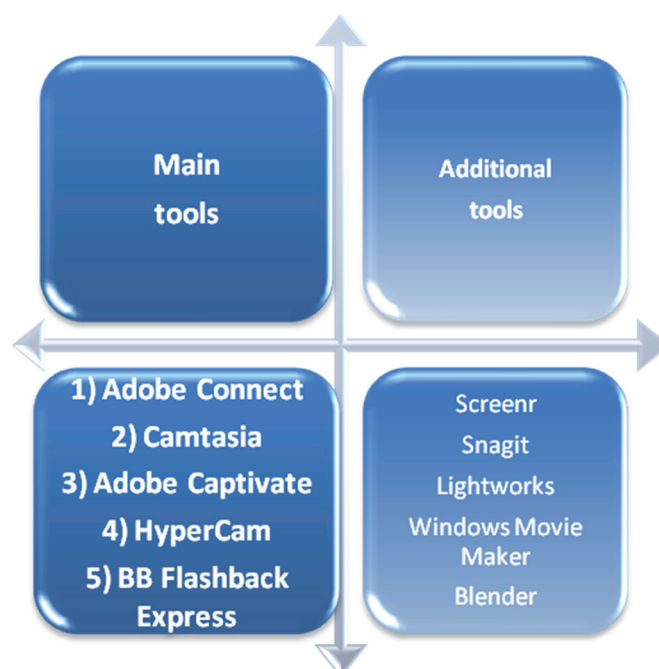


Figure 3. Main and additional tools for making didactic videos

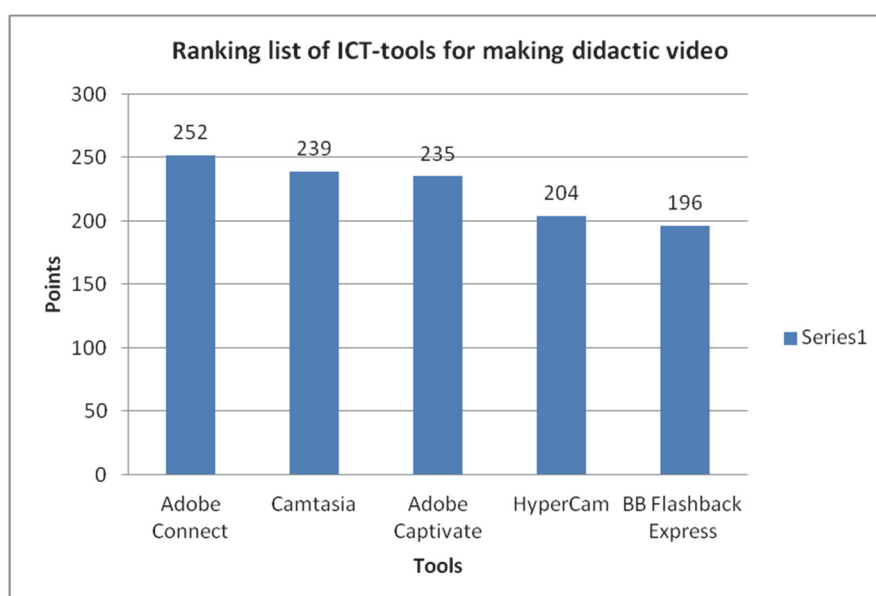


Figure 4. Ranking list of ICT-tools for making didactic video

## CONCLUSIONS

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The reports of research about described activity and tools identified are available in other papers, reports and several didactic videos, produced by the researchers about the activity, described in this article and a report identifying relevant and necessary tools has been prepared. In the near future the research results and elaborated tutorials on didactic videos will become a part of the MOOC "ICT tools for effective use in education", prepared by IRNet consortium and planned to be launched in 2016 in several languages.

## ACKNOWLEDGMENTS

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The research leading to these results has received, within the framework of the IRNet project, funding from the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Programme FP7/2007-2013/ under REA grant agreement No: PIRSES-GA-2013-612536

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# Web Based Learning Method of Information Retrieval for First Year Students at University

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## Abstract

*The article presents the results of the research on the efficiency of the “First Steps at FIM” project – FSAF. Almost seven hundred first year students in total participated in the research in the years 2012–2015. The aim of the survey was to prove that the FSAF project is useful and the students are satisfied with it. The methods of quantitative questionnaire survey and qualitative SWOT analysis were used here. The results from the questionnaire imply that 94% of students consider the FSAF course and “Welcome to FIM” lecture to be useful. It was confirmed that the students who are not familiar with the course have less knowledge than those who have attended the course. 72% of assigned questions were answered correctly. Those not knowing about the course had only 68% of answers correct. Out of the total number only 16% of students do not use the course, which proves that the course is useful and popular with most of the students. The SWOT analysis from 2014 shows that the students are satisfied with the information provided in the course. They appreciate instructive articles complemented by multimedia content, up-to-date video records, pleasant graphic design and the search engine function. In the year 2015 was newly implemented Google analytics. The results will be used for the timely provision of information and a quick adaptation of students when entering FIM UHK.*

## Keywords

*Internet marketing. Efficiency. First Steps at FIM project. SWOT analysis. Current information awareness. Multimedia environment. Timely adaptation to university environment.*

## INTRODUCTION

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Motto: *The high level of education in the USA has led to an increased emphasis on marketing targeted at students as well as to increased marketing of colleges and universities as established brands. The growing competitiveness for top students and the interest in reputation and high rating make these institutions create brand image. (Kotler, 2007)*

The study belongs to the field of **internet marketing** which is focused on satisfying customer needs and is carried out via the internet. It is based on a good website whether it is the presentation of an organization or an online store. (FastCentrik, 2014)

The research focuses on the effectiveness of the First Steps at FIM project (further FSAF) which is organized by the Faculty of Informatics and Management (FIM), the University of Hradec Králové. The term FSAF project includes everything connected with

the First Steps at FIM – the implementation team, websites or regular events for students. So the FSAF course is the term used only for the main output of the project, i.e. a website with all useful instructions and up-to-date information about university studies. Thus the students' transition from the secondary school form of studies to the university form is facilitated. The course is continually innovated according to the freshmen's requirements and needs. (Strnadová, 2009, 2011; Feist, 2006)

The FSAF project is developed and regularly updated by selected students of FIM UHK who have been collaborating within their selective projects with PhDr. Věra Strnadová, Ph.D. since 2004. The implementation team also participate in the introductory lecture *"Welcome to FIM"* for freshmen, they make representative videos and annually prepare the SWOT analysis of the course. The slogan of the collaboration: *"First steps at FIM and at once I know everything"* expresses its message. (Pearson, 2008; Devito, 2008; Wrench, 2008)

## METHODOLOGY

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### Objective and methods of research

The objective of the research is to prove that the project First Steps at FIM was effective in the years 2012–2015 (Strnadová et al., 2015c). The data proving the project effectiveness is collected using the methods of questionnaire survey which took place in 2013 and SWOT analyses in the years 2012, 2013, 2014 and 2015.

### Implementation of the research and characteristics of the research sample

The questionnaire survey was processed in an electronic form, 210 respondents participated in it and the results have yielded quantitative data on the usefulness of the FSAF course. Two groups of students were created here – the first group that had visited the course and the other group that had not visited it. The aim of this survey was to prove that the students who know the course have more knowledge than those who do not know it. All the data was analysed using Microsoft Excel program. 400 respondents participated in the research using a SWOT analysis in the years 2012–2014. The output was processing strengths and weaknesses of the course, its opportunities and threats and also reflecting the development of the course over a period of three years. (Svitáková, 2014)

## RESULTS OF THE RESEARCH

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### Questionnaire survey

Links to the questionnaire were sent to students' mailboxes on October 23rd, 2013. It was possible to fill in the questionnaire for the period of two weeks. 210 responses were collected. (Strnadová and Voborník, 2015a)

#### *Division of respondents*

In the total number there were 54 (26%) students of Applied Informatics branch of study, 93 (44%) students of Information Management, 29 (14%) students of Tourism Management and 34 (16%) students of Financial Management (Figure 1). Out of these,

there were 108 men and 102 women. Furthermore, 28 students come from Hradec Králové and 182 students are from elsewhere.

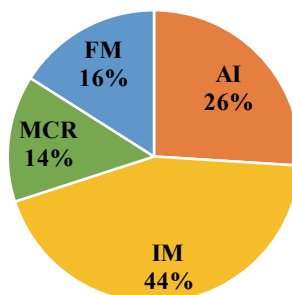


Figure 1: Shares of study branches.

### *Evaluation and visit rate of the FSAF course*

176 persons gave a positive answer to the question whether students know the First Steps at FIM course and 34 persons gave a negative answer. This is favourable data, most FIM students are aware of the course and thus their entry to university life can be significantly eased.

In the next part of the questionnaire only those who knew the course gave their answers. There were five items of interest: I attended the introductory lecture, the introductory lecture was useful, the course provided me with enough information, the course is useful, and the course website is well arranged (Figure 2).

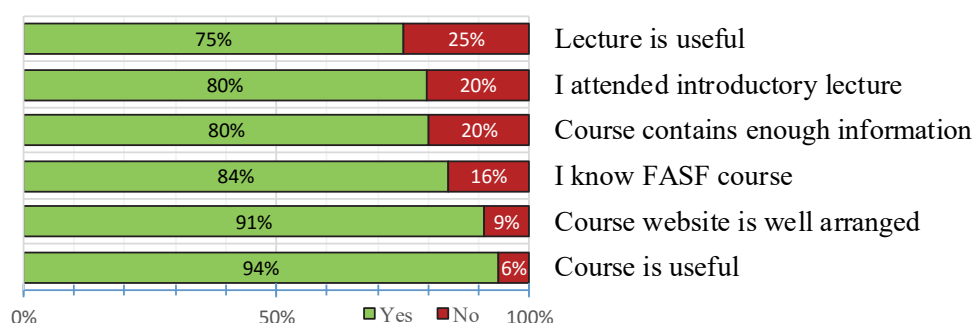


Figure 2: Evaluation of FSAF.

The overall evaluation of the course by students is very positive. Only 16% of respondents do not know the course. The majority of those who know the course is satisfied with the provided instructions and information. The question regarding a visit rate of the course indicated that students mostly visit the course before entering university (46%) and during the first weeks (44%) of their studies (**Figure 3**).

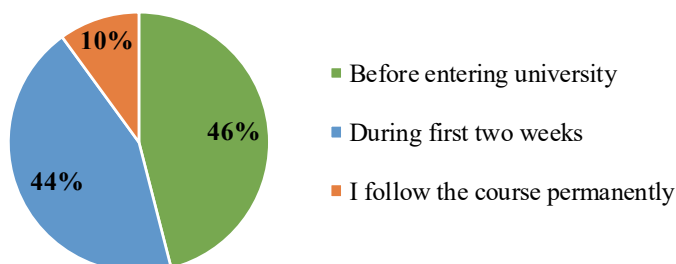


Figure 3: Visit rate of the course.

### *Success and satisfaction rating by students at FIM UHK*

In this part of the questionnaire the students evaluated by scaling their success rate when compiling the first timetable and using ISIT (UHK information system) – Table 1 shows that they can manage both activities.

Table 2: Success of students.

	I managed to compile timetable	I am familiar with ISIT
Very well	78	30
Well	88	104
Moderately	34	65
Minimally	5	6
Not at all	5	5

In the first week of their studies students reported only a minimum degree of stress factors (**Strnadová and Voborník, 2015c**) and the degree of satisfaction with the achieved school results was at a medium level (**Table 2**).

Table 3: Satisfaction of students.

	First week at FIM was stressful for me	I am satisfied with school success
A lot	22	7
Rather more	46	40
Moderately	54	134
Minimally	60	20
Not at all	28	9

### *Knowledge in the field of study administration*

In the last part of the questionnaire students answered the questions directly connected to study environment. Most of the questions were closed, it was therefore possible to choose one of the offered options. Only the questions concerning scholarships and ISIC cards had a polytomic character, it was therefore possible to select any number of answers. Just one combination of answers was correct, that is why it was the most difficult to answer these questions. Figure 4 show how successful students were in their knowledge. Students were divided into three groups: all students, the students who know the FSAF course and the students who do not know the course. From the comparison we can see that in some questions people knowing the FSAF course were more successful, in other questions the situation was opposite.

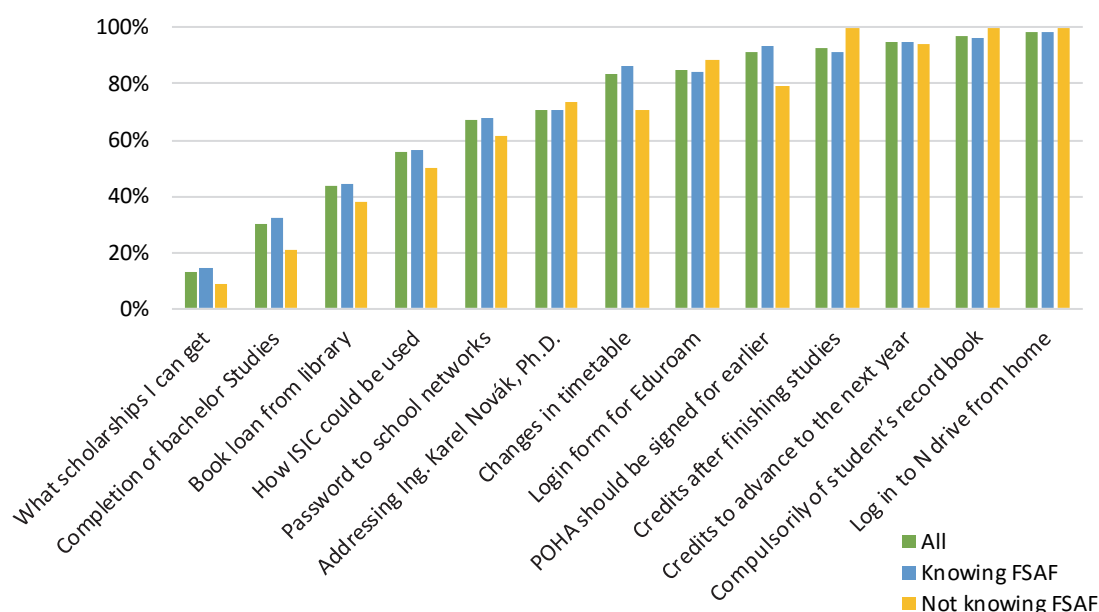


Figure 4: Success rate of answering knowledge questions.

If the right answers per one person are expressed in numbers we will get more accurate results. In Figure 5 there is a noticeable difference between all three groups of students. Those who know the FSAF course were the most successful. From the total number of thirteen questions the success rate of the groups was ranging between 8.85 (68.1%) and 9.31 (71.6%), which is not statistically significant difference.

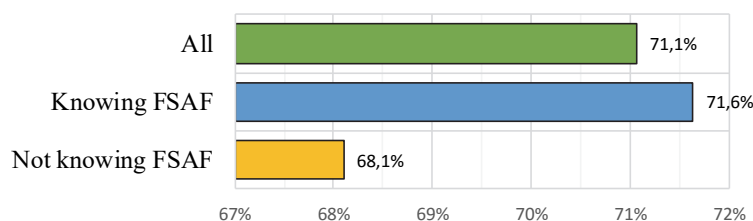


Figure 5: Correct answers per person.

## SWOT analysis of course development in years 2012 - 2014

The development of the First Steps at FIM course can be monitored using SWOT analyses which are completed by students annually. The study compares current years 2012, 2013 and 2014 with one another.

### *Development of sections of FSAF course in years 2012, 2013 and 2014*

In the Figure 6 we can see a visit frequency in the individual sections of the course in 2012, 2013 and 2014. The composition and number of sections is different every year depending on the adjustments according to current requirements of students. *Timetable*, *ISIT*, *Oliva* or *Blackboard* and *First Week at FIM* belong to the most attended sections in all the years.

In 2012 the course contained 18 different sections. The least favourite sections were – Doctor, Internal news, ESN Buddy System and Student's account.



In 2013 a lot of new sections were added. At the time the course contained 32 sections in total and thus students' requirements were met as students had requested new information. *Distance Study, Forms of Study and Faculty Institutions* belonged to the least popular sections. From the new sections the most popular were *Krajta* and *First Week at FIM*.

In 2014 there was also an increase in the number of sections up to 35 sections. The unpopular sections from the previous year *Forms of Study and Faculty Institutions* were remade and achieved higher visit rate. The sections *How to Manage Exams* and *Seminar Assignments* were added which also better reflected the needs of senior students (Figure 6).

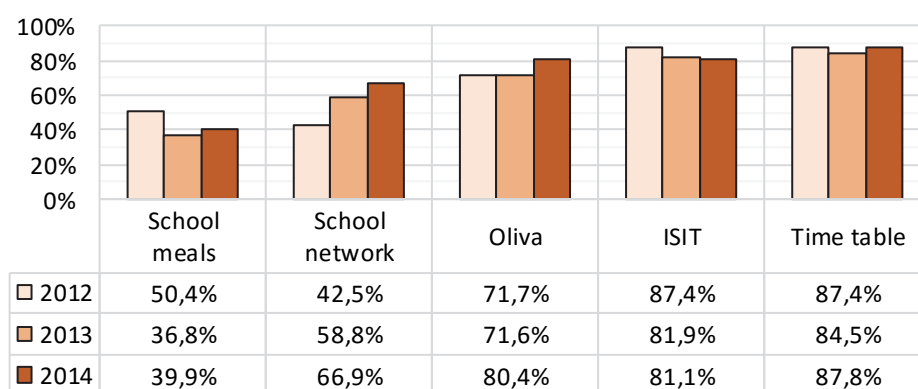


Figure 6: Visit rate of five most frequented sections in 2012–2014.

#### *Changes in SWOT analysis development in 2012–2014*

SWOT analyses reflect the needs of students for whom the course is intended (Střelec, 2012). According to their needs not only individual sections but also the website functionality and appearance are modified. (Strnadová, 2011; Svitáková, 2014)

The opinions on the web graphics are contradictory in 2012. A simple design promotes good legibility of the website but too austere graphics can evoke indifference. Users lack an off-line version of the website, a search engine or a multilingual presentation.

With reference to the information above, the following innovations for 2013 took place: a search engine was added to the website, a graphic design was changed, an English version was being prepared and the article *First Week at FIM* came into existence. This article summarizes the most essential terms and information which students need when entering university.

As we can see in Table 3, in 2013 we can see the same discrepancy between the opinions on the web graphics. Students still criticize the absence of an English version, the virtual tour of school premises or a discussion forum. On the other hand, they appreciate the presence of a search engine, multimedia appendix or up-to-dateness of articles. There are new requirements for connection of websites with Facebook, completing information on Erasmus and adding more images and videos.

Table 4: SWOT analysis of 2013.

<b>Strengths</b>	<b>Weaknesses</b>
Well-arranged information	Lack of information on authors of the course
Credible information	Absence of information on Erasmus
Extensiveness and accuracy of information	Lack of information on teachers
Multimedia appendix	Forum, chat, discussion
All in one place	Complicated address - pknf.uhk.cz better
Without advertisements	Often long texts
Search engine	Orientation plan of building, virtual tour
Attractive design	Insufficient promotion
Experience of implementation team	Non-existence of offline course (pdf, doc)
Up-to-dateness	Graphics of websites
Project students to students	Monolingual course
Optimization for all search engines	Utilization only for freshmen
<b>Opportunities</b>	<b>Threats</b>
Better promotion	Not up-to-date content
Tour of the building, plan of buildings/FIM	Lack of interest in the course
Forum or box for questions	Failure of technical equipment
Connection with Facebook	Attack on server - hackers
New members of implementation team - new ideas	Loss of clear arrangement (too much information)
Guestbook	Replacement by another portal
Sections for individual branches	Break-up of implementation team
Printed version	Loss of support from faculty management
More info on Erasmus (interviews with students)	Negative reviews from students
Information on teachers	Diversion from students' needs
More photos and videos	Competition among universities
Improvement of design	
Increase in usability for higher years	

Thus since 2013 we can see improvements in up-to-dateness of articles and searching on the website which are no more criticized by students. On the contrary they keep objecting to the fact that the course is focused only on new students – therefore the sections *How to cope with exam period* and *Seminar assignments* were added (Table 3).

In the SWOT analysis of 2014 students appreciate the originality of the course, a slogan, video records of the team and instructive animations. Students still lack an English version, a discussion forum, an abridged version for print, better graphic design and the possibility of a virtual tour of university buildings. The following sections are required – an instruction manual how to scan, connection to Wi-Fi via mobile phone, information on parking at the faculty, information on Erasmus and compulsory internship. Based on these SWOT analyses the course has been completed by adding procedures for connecting mobile devices to the Eduroam network and for scanning. Sections have again been upgraded and updated.

In SWOT analysis of 2015 (Table 4) users appreciate an erudite implementation team consisting of students and teachers. Positive evaluation is given to newly implemented tools for getting a feedback Google analytics. Students make use of obtaining information quickly in one place (all-in-one) and have possibility to use experience of graduates. Frequently proposed are the requirements to make the on-line course accessible also to students of combined form of studies (distance learning students (Hubálovský, 2013)) and

to present this project to secondary school's students within the recruitment of new students to FIM UHK.

Table 5: SWOT analysis of 2015.

Strengths	Weaknesses
Erudite team (consisting of students and teachers)	Consultation on the project with a freshman
Representation of people with a different point of view (sport management student, IT, "video man" and a girl element)	Small number of people working on the project
Implemented tools for feedback (GA)	Possibility of dissemination among potentially interested people
Possibility of use of lecture hall, technical equipment and other school benefits	No utilization of distance learning students, Erasmus student trainees from firms as another source of information for students
Opportunities	Threats
Instructions, useful knowledge provided in a clear form	Addressed only some branches of study
All about entry in one place	Competition to get popularity among other „daughter“ UHK events (support of events, competitions)
Majority visits website for its main function (timetables, credit system, first week...)	Mostly students find out about it as late as in the letter of admission. Presentation of the project already at secondary schools – could help a greater number of people get interested in studying
In addition to processed data, experience of graduates is passed (another view)	Focused primarily on full-time students
Possibility to add what they would like to know	

According to information from Google Analytics, nearly half (45.8%) of site visitors really looking for some information and they spend more time on the website (Figure 7). Only 10% of people looking for information with mobile devices (phones and tablets), and the vast majority (90%) opens the site via a computer.

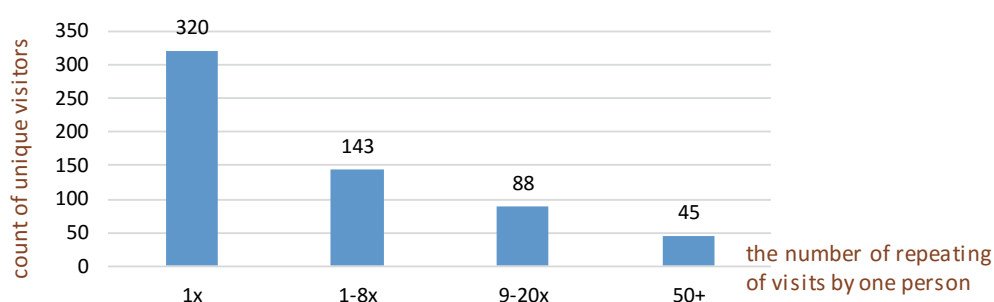


Figure 7: The frequency of repeated visits to the course FSAF in 2015.

## Proposals for the future

A new menu of the course contains seven categories (Table 5): *About FSAF, Instruction manuals, Start at university, How things work at FIM, Life of a student in HK, Student organizations, Searching.*

Table 6: Overview of future organization of the course.

<b>Instruction manuals</b> <ul style="list-style-type: none"> <li>• Entry in student's record book</li> <li>• Timetable</li> <li>• Seminar assignment</li> <li>• Blackboard</li> <li>• ISIT</li> <li>• Krajská (students' forum)</li> </ul>	<b>About FSAF</b> <ul style="list-style-type: none"> <li>• Introductory words</li> <li>• Our team</li> </ul>	<b>How things work at FIM</b> <ul style="list-style-type: none"> <li>• Enrolment in studies</li> <li>• Organization of the year</li> <li>• Credits and subjects</li> <li>• School network</li> <li>• Branches and forms of study</li> <li>• Scholarships</li> <li>• University institutions</li> <li>• Cloakrooms, lockers</li> <li>• Who is who at UHK</li> <li>• Ceremonial occasions</li> <li>• ISIC</li> <li>• Combined form of study</li> <li>• Information for applicants from secondary school</li> </ul>
<b>Start at University</b> <ul style="list-style-type: none"> <li>• Welcome to FIM</li> <li>• Open door</li> <li>• First week at FIM</li> <li>• Students to students</li> <li>• FAQ</li> <li>• Our graduates</li> </ul>	<b>Student organizations</b> <ul style="list-style-type: none"> <li>• AIESEC</li> <li>• Buddy System</li> <li>• Student Union</li> </ul>	
	<b>Life of a student in HK</b> <ul style="list-style-type: none"> <li>• How to manage exams</li> <li>• How to study at university</li> <li>• Transport</li> <li>• Meals</li> <li>• Accommodation</li> <li>• Important places</li> <li>• Free time</li> </ul>	

## DISCUSSION

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The objective of the study was to prove that the FSAF project is effective, useful and students are satisfied with it.

The results of the questionnaire imply that 94% of students consider the FSAF course and the introductory lecture "*Welcome to FIM*" useful. It has also been confirmed that students who do not know the course have less knowledge than those who have visited it. Out of thirteen questions the sympathizers of the course answered correctly 72% on average. Those who do not know the course gave the correct answer to 68% of questions on average. Moreover, there were only 16% of students not knowing the course which proves its popularity and usefulness.

The SWOT analyses of 2014 and 2015 show that students are satisfied with sufficient information in the course. They appreciate instructive articles complemented by multimedia content, up-to-date video records, pleasant graphic design and the function of search engine. Positive evaluation was also given to an erudite implementation team selected from students and teachers, newly implemented Google analytics. Students make use of fast search for information in the form of all-in-one and at the same time graduates' experience is available for them. The development will feature extending the on-line course for students of combined form of study and making it visible at secondary schools. However, the most important finding is that the course is really evolving according to what students want. This guarantees its constant popularity and up-to-dateness.

## CONCLUSION

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The project First Steps at FIM is characterized by most students as very useful and unique. During its ten years of existence it has helped a large number of students and has become an inspiration also for the Faculty of Education UHK. We bring current information

to students, they can use multimedia environment and adapt to conditions of FIM UHK in due time.

## ACKNOWLEDGEMENT

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This paper is supported by the project No. CZ.1.07/2.3.00/20.0001 *Information, cognitive, and interdisciplinary research support*, financed from EU and Czech Republic funds. This paper is supported by the Excellence Project No. 2208: *The ICT reflection within the cognitive processes development*. The paper is supported by the SPEV project FIM UHK 2016.

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# Adaptive Education Evaluation

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## Abstract

*As far as the pedagogical process is concerned, an evaluation means evaluating textbooks or study materials a) through reviews before the instruction or b) by students – questionnaires through which students evaluate the instruction. For several years, the research at the Pedagogical Faculty of the University of Ostrava has been focused on the theory of adaptive e-learning and its testing in practice. The paper deals with one of the main parts of the stated issue – an evaluation of the educational process and adaptive textbooks. Evaluation is conducted after the realization of the analysis of the protocol of students' behavior in the on-line mode. The paper describes the theoretical proposition of the evaluation and its verification in practice.*

## Keywords

*Adaptive learning. Adaptive LMS. Textbook evaluation. Education process evaluation. Student behavior analysis.*

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## PERSONALIZED ADAPTIVE LEARNING

Until recently, individualized learning, or the instruction of an individual was rarely used. It was only used in extracurricular or optional education (e.g. language schools, art study programs, sports schools, etc.). Due to the high number of students and the number of students per teacher, it could not be used at any level of classical schools (Magdin, Turčáni, 2014). Moreover, the textbooks were intended for all students. Even though the textbooks were created by qualified pedagogical experts, they were not suitable to all students (Drápela, 2013).

The rise of computer networks and the expansion of the Internet among the general public led to the new educational possibilities (Chen, 2005). However, the technological possibilities are ahead of the pedagogical software (Sak, 2007). As a result, the e-learning possibilities cannot be used to the fullest and all students still use the same electronic textbooks. Not only would the HW and SW tools enable individualized instruction, but also an instruction which could be adapted to every student's characteristics and abilities (Magdin, Turčáni, 2015a, 2015b).

The main reason why there are not different textbooks for different types of students is the insufficiently explored issue of student types, their learning styles, and the optimal methods for teaching certain types of students. It is a multidisciplinary issue requiring



cooperation of pedagogues, psychologists and specialized informatics (Magdin, Turčáni, 2016).

A team has been assembled at the Department of Information and Communication Technologies of the Pedagogical Faculty of the University of Ostrava. The team of experts, which deals with the abovementioned problem, introduced the theory of adaptive education. The theory is being verified in practice and extended by the results of the related research. Apart from the members of the department, a number of Ph.D. students are participating in the development of the theory. A number of dissertations on the topic have been successfully defended.

Generally, an adaptation of education means the changes in the instruction of the identical curriculum, which are carried out in a different fashion so it would suit the needs of every student. Ideally, all e-learning possibilities (i.e. the LMS tools) would be used. The Internet and computer can be used for the presentation of the created study materials. However, both means can also be used for an adaptation of education, i.e. automatic individualization of instruction based on what student it is currently teaching.

A number of partial problems can be solved by automatic individualization of education:

- How to create the textbooks so they would come in different teaching style variants for different LS,
- What characteristics determine the student's learning style (LS),
- What instruction strategy to use for the consolidation of the acquired knowledge,
- What automatic methods can help in the acquisition of feedback on the effectiveness of instruction,
- Teaching style (TS) types and their characteristics,
- Which TS should be used for a particular student and their LS in order for the best possible result to be achieved.

Apart from the mentioned partial problems, the proposed solutions require the creation of a new learning management system (LMS). None of the existing systems contains those options (Kostolányová, 2012).

To solve the problems, the initial theory of adaptive education (TAE) proposes a possibility, the basic principles of which will be introduced. Moreover, the characteristics will be highlighted which will be used for the evaluation of adaptive e-learning textbooks.

## **Student's Learning Style**

In order for individualized education to be managed in an individualized manner, the program that manages it needs to know the information about the student's learning style (LS). A large number of theoretical pedagogues and psychologists specialize in the LS theory. They defined a number of characteristics – students' qualities – influencing LS. An extensive analysis led to the definition of a tuple of mutually independent characteristics determining the student's LS, which were published in (Kostolányová, Šarmanová, Takács, 2009).

The characteristics are as follows: learning tactics containing orderliness (studies systematically and sequentially or non-systematically and randomly), social aspect (prefers

learning on their own, in a group, in a pair), affective aspects (motivation for study – inner, outer), approach to study (depth, strategic, surface), sensory preference of perception (verbal, visual, auditive, kinaesthetic), degree of self-regulation – the ability to manage one's own studying, information processing (theoretical derivation, experimentation), information processing procedure (detailed – bottom to top, holistic – top to bottom). Moreover, there is success rate (talent for a particular subject), which is a dynamic attribute (Dvořáčková, Šarmanová, 2009).

### **Adaptable Study Material**

It is necessary to mention that when referring to an e-learning textbook, we mean the complete study material which includes not only the text part with graphs, images, etc. but also all the accompanying videos, multimedia, animations, single-purpose study programs, supporting pedagogical SW, websites, etc.

As far as adaptability is concerned, there is another question: Which methods to use in order to make the textbook adaptable to every current student's LS?

The following paragraphs will not focus on the factual accuracy and didactic quality of the textbook. Those are being evaluated in the following chapters.

The creation of a different version of the study material for every student type (often named) is one of the possibilities, which is preferred by the majority of experts who specialize in LS. As far as 2-3 qualities with two poles (has – doesn't have a quality) are concerned, the amount of variants is reasonable. However, if the number of characteristics is higher, the amount of variants would be unacceptable (e.g. there would be  $214 = 16,384$  types for only 2 qualities of each of 14 characteristics forming the basic model).

As a result, a different method has been selected. The characteristics, which require a different formulation of the curriculum, will be created in variants. These will be as follows: 4 sensory variants (which require different "active" words to be used in the text and different types of multimedia) and the success rate (a different level and extent of instruction are required). 3 levels of the depth of instruction have been selected. Overall, there will be  $4 \times 3 = 12$  variants of instruction.

The other characteristics are being approached differently. The textbook is divided (in a classical manner) into chapters or units. The unit contains new information, i.e. new terms. The unit of information (e.g. one new term) has been named a frame (Kostolányová, 2012).

Analyzing the ways in which the variants of the study material should differ regarding different values of other students' qualities has showed us that they differ particularly in the order and the choice of sub-sections within the frame. For example, a student who is theoretically equipped and successful appreciates the following order: theory, explanation, examples, verification; a student who is unmotivated and less successful, on the other hand, requires motivational examples, a more detailed explanation, theory, verification and motivational praise. The adaptation "rules" (i.e. choosing and sequencing the sub-sections of the study material in order to fit every student's LS) can be formulated similarly. Consequently, every frame has been divided into layers. The following layers have been defined: testing (tasks and practical tasks, theoretical questions), instructional (fixation, semantic, theoretical, of solved examples and of practical examples), and special (navigational, motivational, literature, formulation of aims). It has been proven that these

layers are in accordance with Gagné's theory of the education process, didactic principles, and other pedagogical-psychological principles.

As a result, the instruction has been divided into units and frames. Every frame contains sensory and depth variants, which are further divided into layers. Neither variants nor layers are obligatory. The author of the study material decides which of them are appropriate for a particular subject.

### **Teaching Style For Student With Known Learning Style**

The program managing individualized education has been named the Virtual Teacher (VT). The program is designed to create an optimal version of the study material from the author study material. The optimal version of the study material is structured into frames, variants and layers for the current student. The frames, variants and layers are defined by students' LS characteristics. The entire process is divided into 2 phases.

As far as the first phase is concerned, the VT defines the so-called current student's optimal learning style (OLS). It means that it compiles a theoretically optimal selection and sequence of every frame's layers which are valid for any study material. However, not all of the variants and layers for every frame need to be included in the actual study material (see the end of Paragraph 1.2).

That is the reason why the second phase of the VT is necessary. Again, the second phase is carried out for every current frame: The so-called actual learning style (ALS) with the frame adaptation adjusted to a real frame is defined on the basis of the student's OLS. Possible missing variants or layers are replaced by the closest ones or omitted entirely.

### **Implementation of Adaptive Education through Adaptive LMS**

The proposed detailed theory of adaptive education needed to be verified in practice. In order to accomplish that, it was necessary to create an LMS that would be able to use the expert rules to create the optimal version of a study material for a particular LS from a detailed study material. In 2010-2012, teachers and students of the University of Ostrava and VŠB-Technical University of Ostrava collaborated on the development of such system. The system was realized as the LMS Barborka 4. However, the versions 1-3 contained only partial solutions of adaptivity. Two ESF OP VK projects supported the research. The system is still being developed and new rules and functions are being added (Šarmanová, Kostolányová, 2008).

The LMS is divided into the following modules: Author (storing and modification of study materials), Expert (an expert system for the rules of the VU, algorithms of the Virtual Teacher, a system for the data analysis), Student (identification of students and a questionnaire for their initial characteristics + the instruction), Tutor (submission of tasks, realization of tests, organization of education, etc.), Admin (system administration). The Author, Student and Expert modules are important for adaptivity. Firstly, their original scope will be described. The following chapters will focus on the addition of two sub-modules to the Expert module. These sub-modules are used for the evaluation of textbooks.

## Author Sub-system

It has already been mentioned that the author is the one who makes the decision about the factual content of a study material. However, in order for the author to be able to adjust the study material so it would meet the requirements for the structuring of a workbook into frames, variants and layers, they need to be acquainted with the methodology of the processing of variants, the meaning of types of layers and the TAV (Kostolányová, 2012).

The layers need to be self-supporting in order for the frames to be adaptable (i.e. a different sequence of their layers could be used). The entire frame is required to provide quality instruction even when a different sequence of layers is used. For example, the following sequence is preferred by the student-experimentalist: practical example, explanation and theory. On the other hand, the student-theoretician prefers the following sequence: theory, explanation and practical examples.

As far as the sensory variants are concerned, it is vital that the author is acquainted with the recommended formulations for different sensory types of students. However, the author often belongs to one of the types. As a result, their language is influenced by the type to which they belong. Consequently, the author is required to learn to express the identical phrases in a different language for different sensory variants. For example, as far as the auditive student is concerned, "auditive" words such as "let's discuss", "let's listen to", "the sentence goes...", etc. should be used; as far as the visual student is concerned, the author should use "visual" words such as "let me show you...", "we can see that...", "varied", etc. When addressing the other sensory types, the author should follow a similar pattern.

As far as the depth of the instruction is concerned, the author needs to imagine to be instructing the average student. However, as far as the above-average student is concerned, the author needs to make the instruction more interesting so the students do not become bored. On the other hand, the slower student requires a more detailed instruction (the author also needs to adjust the pace of the instruction).

Every individual layer of the finished study material in the LMS can be stored and modified separately. Parts of the study material need to contain the so-called metadata which store the system information about the structure of the study material, in order for the VT system to be able to distinguish between the variants and "know" which layer belongs to which variant and frame. That presents another difficult task for the author.

It needs to be stressed that during the actual education process the author does not need to pay attention to when a particular variant, selection or the sequence of layers is used. It is the VT that deals with this issue (in contrast to programmed education which is still frequently used in adaptive systems). The "programming" of the education process is automated not only for the average student but also with regard to the student's LS.

## Student Sub-System

The Student module is user friendly. After the first log-in the student is asked to fill out a questionnaire. The questionnaire helps determine the initial characteristics for the student's LS. The questionnaire was compiled by a psychologist (Novotný, 2010).

Afterwards, the student chooses the course and unit. Then the student is presented with a series of frames in the sequence of layers adapted by the VT according to their LS. As it is usual in e-learning, the student then chooses their own pace of education. However, the student does not need to follow the variants and the sequence of layers that is offered to them by the VT. The student is allowed to select another existing neighboring variant of instruction (of another sense or depth) or move on to another frame in the unit at any time.

The education process protocol records every "mouse click" of the student in every mode. Interesting facts about the student, the study material or the rules for the management of instruction can be revealed by the analysis of the protocol.

## **DEVELOPMENT OF THEORY OF ADAPTIVE EDUCATION**

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The 2012 TAV contained the defined basic principles of the adaptation of study materials depending on particular students' LS. During the realization of the principles in the LMS, their verification, pedagogical experiments and theoretical discussions of the entire group of researchers, a number of other pedagogical-psychological and implementation problems concerning the theory were defined. We will focus on the ones that have already been solved.

The professional and didactic level of the adaptable textbook is an important factor conditioning the quality of instruction. However, the authors do not have enough experience with it because it is a new approach to the adaptability of study materials. Originally, only 12 such textbooks were created. Moreover, those textbooks were created only for several units. Subjects from various fields were intentionally selected: science subjects (physics, mathematics, biology), foreign language (English), informatics (databases, algorithms and programming, digital photography), technical (material science), pedagogical (e-learning technology).

Firstly, every author created their own study material. Afterwards, a number of seminars were held. During the seminars every author presented their experience and propositions concerning methods for the creation of the textbook and its variants. It was interesting that all authors agreed on the identical optimal approach to the textbook creation. Based on this result, an MS Word form, which was further used, was proposed for the authors. Not only does the form contain a predefined basic structure of the frame with its layers, it also contains a place for the accompanying metadata (which the author must specify when inserting it in the LMS).

This pattern was then successfully used by other authors. Because the newly created parts of the study material are often modified, it is not appropriate to insert them directly in the LMS.

That is how the technical part of the creation of the adaptable study material was carried out. However, what remains unresolved is the issue of the professional and didactic evaluation of the textbook.

Evaluation was the topic of two dissertations of students of the ICT in education study program. However, they evaluated different facts and used different methods. Firstly, general methods of evaluation will be described. Afterwards, we will proceed to the

description of the newly proposed method. The fact that it is carried out without further involvement of authors or opponents makes it interesting.

## INSTRUCTION EVALUATION

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Evaluation or grading is used in all areas of life. However, it is not always called evaluation (Winfrey, 1999; Attwell, 2006). In pedagogy evaluation is sometimes divided into:

- Evaluation of educational programs,
- Evaluation of textbooks,
- Evaluation of educational needs,
- Evaluation of the educational environment,
- Evaluation of real instruction.

We will focus on the last point – evaluation of real instruction.

From now on, evaluation of textbooks will include all methods which can contribute to the evaluation of the success of instruction according to the evaluated textbooks:

- Professional or pedagogical reviews are often used. They are written by reviewers (experts in particular fields) when a textbook is created but before it is used in instruction. Sometimes the so-called layman review, which is written by a potential student, is used. The author of the textbook can modify the problematic parts according to the suggestions stated in the review.
- However, experience shows that the reviews not always stress all of the imperfections. It depends on a number of factors: the detail of the review, a reviewer's personal opinion on the form of instruction, etc. The reviews usually reveal the obvious professional errors.
- Especially at universities, evaluation questionnaires or written suggestions, which are written by students who completed the course in which the textbook is used, are a necessity. As for daily attendance study, the evaluation cannot distinguish between the impact of the teacher and the textbook on the student's overall contentment with the instruction. As for e-learning education, the impact of the textbook prevails. As a result, a student evaluation is of greater importance.
- Once again, experience shows that students' and reviewers' opinions on the quality of the textbook differ as they can prefer different points.
- The student's behavior (when they are logged in the system) is often recorded when the instruction is managed by the LMS. Usually, every mouse click of the student on the following function in the system is recorded. The detail of the protocol depends on how detailed is the structure of the textbook. The protocol is not always automatically analyzed. In such cases it needs to be analyzed by the teacher.

We will introduce an original method which automates the analysis of the education process protocol and thus objectively evaluates students' behavior in the on-line instruction.

## **EVALUATION THROUGH COURSE OF INSTRUCTION PROTOCOL ANALYSIS**

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In the adaptive LMS, the entire education process of every student is being recorded: every mouse click, every move to the next layer, every time the student deviates from the recommended educational sequence, every answer, etc. Extensive data are gathered which, when analyzed, may provide feedback on the education process. The instruction analysis has three main parts:

- From the point of view of the correctness of the author study material,
- From the point of view of the student's learning style characteristics,
- From the point of view of the correctness of the rules managing the education process.

We will focus on the analysis of the effectiveness of instruction from the point of view of the correctness of the author study material (Dvořáčková, 2016). It is evaluation of the course study material based on the monitoring of a number of actually completed educational processes. Not only opinions and feelings of students from the evaluation questionnaire are being analyzed, but also their real behavior during the education process. The analyses assume that the characteristics of all students are correctly set and the educational rules are correctly formulated. It is aimed at specifying the parts of the study material that are either unsuccessful in general, or for particular types of students.

First there is a chart concerning the existence or absence of all types of layers of every variant, every frame and every unit of the textbook. It is a different version of the list of the textbook layers than the graphic representation through the semantic network. The missing layers are highlighted and the name or ID of every layer is listed. It helps the author to better and faster understand the following results.

### **Main Characteristics of Subject Instruction**

There are two charts in the instruction protocol: the first, which is the chart of the student's actions, contains 38 attributes (which subject, student, action and its circumstances, student's behavior and knowledge) while the second one, which is the detailed chart of individual answers of testing layers, contains 15 attributes. For the purpose of the analyses, the basic identifier data need to be preprocessed first: the other attributes – subject layers, student – need to be added, the time spent on every layer needs to be calculated, some of the attributes need to be categorized and a number of derived attributes need to be calculated. It is a time consuming calculation, the result of which are 2 charts with 69 and 41 attributes, respectively.

In order to allow the author to preview the instruction data, the basic statistical characteristics of all attributes need to be calculated first. These are: frequency, domain range, average and median. The values offer useful information such as the number of students who completed the course; the number, length and order of student sessions; the time students spent on educational layers; the extent to which students manually intervened into the management of instruction; learning-stylistic characteristics of students; the types of layers presented to students; learning-stylistic characteristics of layers; the types of testing layers (questions); individual testing question success rate of students; the number of answers to the questions; the correctness of students' answers, etc. (Dvořáčková, 2016).

As far as the testing layers are concerned, we assume that the knowledge, represented by the number of students' correct answers, should increase as the instruction progresses. Since the complex instruction is using 4 modes:

- First reading without testing,
- Common instruction with continuously asked questions (lower success rate),
- Repetition with consultation mode (improved success rate),
- Real testing at the end of the course (high success rate),

the results within the modes should be improving. Therefore, the results are calculated not only for all the modes together, but also separately for the three modes that use testing layers. They provide information about whether or not the level of students' knowledge increases with the level of difficulty.

Apart from simple statistics, the correlation of all attributes and the main components are calculated. Those can provide useful information about possible hidden variables – main components represented by the known attributes.

### **Analyses of Causes Concerning Level of Knowledge, Learning Time, Student's Intervention into Instruction**

The new analyses aim to answer 3 main questions:

- Under what circumstances (values of attributes which may be the cause) do students achieve different levels of knowledge?
- Under what circumstances do students spend a different amount of time on individual parts of the study material?
- Under what circumstances do students find the offered instruction insufficient and search for other variants?

Methods of acquiring knowledge from data, particularly finding associations and methods of construction of the decision tree could be used. Those can find all the combinations of attributes – potential causes, which result in different values of attributes, i.e. consequences. This can result in the occurrence of not only the expected relations between attributes, but also of hypotheses – associations between attributes – which no one thought of exploring yet.

The already mentioned 3 attributes are the consequences of the wanted hypotheses: the level of students' knowledge – categorized into 5 stages, the categorized time spent on individual layers and the sign of a manual switchover of the student.

### **Realization of Evaluation Methods**

The entire evaluation system, based on the analysis of the instruction protocol, was implemented into the abovementioned adaptive Barborka 4 LMS. It was included in the Expert module as an independent subsystem of Evaluation. It can be used for every subject/course which has already been taught in an adaptive LMS.

The evaluation system contains a number of methods of data preprocessing, calculation of statistical characteristics of the textbook and the process of instruction of the evaluated subject, calculation of correlations and main components, the method of



finding associations and the method of construction of the decision tree. The user can manage the subsystem easily and choose individual analyses.

### Verification of Evaluation by Protocol Analysis

2 subjects with the already finished pilot instruction were used for the debugging and verification of the Evaluation subsystem. The subjects were Business English for University and Mathematics, Revision for 9th Grade of Elementary School.

The statistics showed that:

- 277 students in 2099 sessions (logging in the system) participated in the instruction; 1 to 35 sessions per student, mainly 4 sessions; the study time was mainly Wednesday around 4 p.m.;
- They completed 45 instructional and 29 testing layers, on which they spent 1 – 1,200 seconds (too much time probably means that the student has logged out of the system).

During the analysis of the causes a number of associations was found, some of which were expected and some (a number of interesting relations was found) were not.

Every relation is formulated as a rule of the IF – THEN type where IF is a cause in the form of elementary conjunction of cause attributes and THEN is a consequence, i.e. the value of a particular attribute. The reliability is the percentage of valid cases (fulfilling both cause and consequence) of the cases fulfilling the cause. The support is the number of cases fulfilling the entire association.

Out of the 267 resulting associations, we will list a concise summary.

1. Officially the result is presented as follows:

$$skin=(76-100) \rightarrow proc=0, podp=30, spol=85\%$$

Verbal interpretation of this rule:

Highly (76-100) kinaesthetic student ( $skin \in <76,100>$ ) has a zero knowledge result ( $proc=0$ ) in 85% of cases, which is in 30 cases.

More detailed interpretation of this rule:

The textbook is not suitable for kinaesthetic students; it either does not contain the kinaesthetic variants which are replaced by the less suitable ones, or are not created correctly for kinaesthetic students (statistical data show that the kinaesthetic variants do exist but do not cover all frames).

As far as other results are concerned, we will present only their interpretation:

2. If the depth=1 (the variant for advanced students with high success rate), the knowledge result is zero in 9 cases, which is 75% of cases. Therefore, testing layers in depth 1 are too difficult for successful students of all types.
3. If a type of question=created (open question without any offered variants of answers), the knowledge result is zero in 24 cases, which is 80% of cases. Therefore, open questions are less successful than closed questions.

4. If the number of offered variants of answers is high (>5), then the time spent on the question is (0-2 seconds). Therefore, students do not read the offered variants if there are too many of them.

We will present one more result as an example of the detailed evaluation of individual questions:

5. If an ID\_Tlayer=TVrs000024, the knowledge result is zero in 20 cases, which is 80% of cases. When the question is answered incorrectly in 80% of cases, the problem will lie either in previous instruction or in an incorrect formulation of the question.

52 students in 1 to 10 sessions participated in Revision in Mathematics; again, they spent 1 – 1,200 seconds, mainly on Tuesday at 8 a.m. They answered 132 questions.

Here are some of the interesting results:

1. The question Tvrs000066 was presented to students much more often than other questions (109 times). However, it may have been the author's intention and as such it should be examined.
2. According to the median, when compared to other layers, students spent a relatively large amount of time on the layer Tvrs000076 (181 seconds). It is possible that students do not understand the given layer and its content or the content is too difficult.
3. If a type of Tlayer=task (application task, not theoretical question) and at the same time it is Saturday and at the same time the time spent on the layer is (0-2 seconds), the knowledge result is zero in 6 cases, which is 75% of cases. Therefore, on Saturdays students were probably only "clicking" with no intention of answering the questions.

The results were presented to the authors of both subjects for evaluation. Both agreed that they found a number of results inspiring as far as both the modification of the existing version of the textbook and the creation of other versions or other textbooks are concerned.

## CONCLUSION

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In conclusion, we can say that:

- The formulated theory of adaptive education was incorporated in the new type LMS including all described possibilities of automatic adaptation of the study material according to the individual characteristics of the student's learning style;
- The theory has been expanded, among others, by the analysis of the education process protocol which will enable a detailed evaluation of the study material based on students' knowledge and behavior during instruction.
- The abovementioned theories and methods of evaluation have been successfully verified by a pedagogical experiment and an author interview.

and that the theory has been implemented into – so far pilot – practice in a number of subjects.

The proposed theories did not remain only at the theoretical level as there are tools for their practical use.

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Section:  
**Learning/Teaching Methodologies, Assessment  
and Learning Environments**

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# Attitudes and Expectations on Virtual Environments of the Universities

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## Abstract

*The article compares students' replies to a poll on topical issues of electronic education introduction in Ukraine and Slovak Republic. The poll represents a research instrument of e-learning aspects within European research project IRNet – "International Research Network for study and development of new tools and methods for advanced pedagogical science in the field of ICT instruments, e-learning and intercultural competences". This paper discussed the poll results of students of two universities: Constantine the Philosopher University in Nitra (Slovak Republic) and Dniprodzerzhinsk State Technical University (Ukraine) which are the partners within the research project IRNet. In particular, the paper examines information competencies, the commitment and the willingness of students to study in e-learning system. It is proved that the use of elements of e-learning is a topical alternative teaching method and the essential support to traditional education. The article presents general requirements for distance learning systems and organizational actions that have to precede the process of their implementation.*

## Keywords

*E-learning. E-learning Content. Distance Courses. University website. Educational resources.*

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## INTRODUCTION

In modern world computers and information technologies are increasingly seen as means of acquiring knowledge, and with the development of distance, electronic and blended learning their use becomes an integral part of education on all levels and in all forms. International experience of creation, implementation and use of electronic and distance education demonstrates its effectiveness and prospects (Harry & Magnus, 1993; Benigno & Trentin, 2000). Problems faced by modern e-education are pressing and widely discussed globally. A lot of success and failures of using e-learning arise from the administrative system of education, its structure and motivation in the educational environment (Alfadly, 2013). Today, students consider for granted having online access to all significant information in attended courses including study materials, educational

software etc. They use the possibility to contact teachers via e-mail, to discuss in discussion forums, they submit their assignments using online environment and they are tested and evaluated within the online environment (Michaličková and Lovászová, 2014). Subjects of research in the field of e-learning are:

- models and forms of e-learning. Also analyzed are forms of organization of e-learning system, management of e-learning system (Emelyanova & Voronina, 2014; Balogh & Koprda 2014), pedagogical aspects of individualized teaching approaches within established curriculum and programmes implementation of effective forms and representations of e-lectures and materials for acquisition of practical knowledge and skills (Moreno, Ozogul & Reisslein, 2011). Particular attention is paid to the development and implementation of virtual laboratories (Johnson, Reisslein & M. Reisslein, 2014), which will enable students of students of engineering and technical paths to obtain practical skills, to conduct research, technological experiments, to model complex processes and systems etc.;
- software technologies used for implementation of distance learning systems (Lin & Hsieh, 2001; Morze et al., 2015). In this case the following questions are also discussed: effective administration of e-learning systems, optimal storage of teaching materials, methods of optimizing the processing of information in databases and knowledge used for storage of educational materials, creating of new formats for data storage of large volumes etc.;
- innovative methods of presenting educational materials, the use of multimedia (Fisher, Exley, 2014), video conferencing, chats, interactive learning support systems;
- methods and forms of knowledge assessment (Webster & Hackley, 1997): both by the student himself, and by the educator. There is a lively debate about the effectiveness of tests as the main form of knowledge assessment. Discrete or continuous control over the knowledge acquisition is discussed (Volery & Lord, 2000);
- quality assessment of distance learning systems (Selim, 2007; Bryancev, 2008). Criteria for quality assessment have been grouped into several categories (Papp, 2000; Skalka et al. 2013), which allow to evaluate the effectiveness of the system by all parties of the educational process, given the level of acquired knowledge, overall satisfaction with the distance education activities, the time needed to study information in comparison with traditional education etc;
- innovative methods of improving collaboration skills of the 21st century (Morze et al., 2015; Smyrnova-Trybulska, E, 2014; Noskova et al., 2016; Munk et al., 2015).

The two universities, discussed in this paper – Constantine the Philosopher University (UKF) in Nitra, Slovak Republic and Dniprodzerzhinsk State Technical University, Ukraine (DSTU) – are partners within a research project «International Research Network for study and development of new tools and methods for advanced pedagogical science in the field of ICT instruments, e-learning and intercultural competences». The project is divided into 7 working packages (WP). This paper is related to work package 2 (WP2), entitled «Analyses of legal, ethical, human, technical and social factors of ICT and e-learning

development and the state of intercultural competencies in every partner country» and it aims to uncover views and preferences of students of both universities, their wishes and concerns, their general attitude to ICTs in order to see perspectives and problems in development, implementation and management of e-learning. The authors see the overall result of this research in determining the direction of further development of e-learning in higher education based on the differences and similarities between the above-mentioned universities.

## **RESEARCH METHODOLOGY**

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In this paper the authors set themselves a goal based on the opinion of IT students to see the prospects and problems of development, implementation and operation of e-education system DSTU and UKF. Most important opinion for this research is the one expressed by IT students, who are the most open to the idea of using e-learning system. This hypothesis is based on the fact that their competence in the field of IT allows them to migrate to e-education system in the course of their training quite easily. The authors believe this article will bring about the discussion of development and implementation of e-education to IT students. At that, students' opinions, preferences, demands and attitude to education via information technology will be taken into account.

The first survey was held during the Work Package 2 of international project IRNet - International Research Network for study and development of new tools and methods for advanced pedagogical science in the field of ICT instruments, e-learning and intercultural competences financed by the European Commission under the 7th Framework Programme, within the Marie Curie Actions International Research Staff Exchange Scheme. The survey was held with the method of computer questionnaire, anonymously in May 2014 after their classes at the university. Only multiple-choice question and Likert scale were used.

Dniprodzerzhinsk State Technical University was chosen as the first object of research. They do not use any kind of learning management system. The respondents were 184 extramural and full-time students, of which 49.46% were women and 50% men, 75% of them are junior students (and third-year students), and 25% are respectively senior students (bachelors and masters).

Constantine the Philosopher University was chosen as the second object of the research. Moodle is used as a central environment for all faculties and all departments. There were 92 from extramural and full-time students took part in the survey, 11 of them were a woman and 81 men, all of them students of study program "Applied Informatics". The survey covered 58 students in the bachelor and 34 students in master study program.

## **RESULTS**

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The results presented here are devoted mainly to the analysis of e-learning aspects, excluding the details of intercultural and international communication.



## Study materials

The data obtained during research indicate that most DSTU students (58%) quite rarely consult the information presented on the university website and get important information from other sources. About 30% of students would like to see teaching materials and literature on the University website, 15% information about events and activities conducted at the university, 12% schedule, sessions and consultations. In this context, we would like to note that DSTU already has information portal where teachers can spread electronic version of teaching materials for courses, and students can use them in their independent work and prepare for classes. The results obtained at UKF confirm that the website of the university represents the main source of information about the events, schedule of academic year and contacts with teachers for UKF students. They mostly use the website for finding the basic information about the particular person or event, but they are not interested in full-texts and journal articles. Website of UKF is a fundamental crossroads to information on training and educational resources.

Students are interested in teachers' and other students' activities in the social networks. Almost 92% of students surveyed at the University pages on social networks. Activities of others can motivate students to be more active themselves. However, they are not motivated for active participation and creating the community; only 6% comment the social status and only 2% are active in creation of content (photos, video, etc.).

## Organization of lessons

The respondents replied which types of classes they prefer. It was found that almost 77% prefer traditional classes in this way or another (Fig. 1):

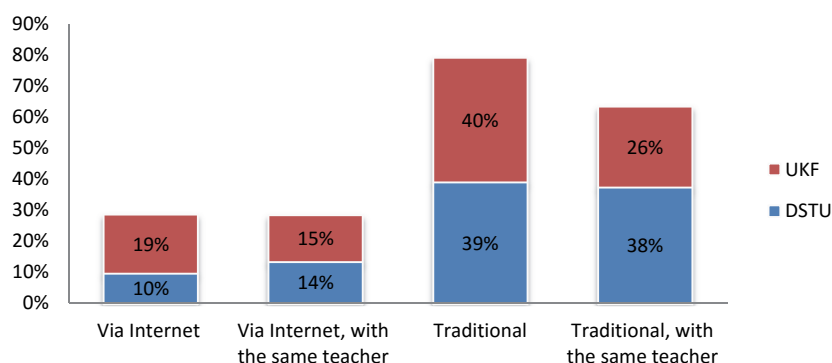


Figure 1: The comparison of using the educational system preference.

The main motivation for the choice of traditional classes is personal contact with the teacher, and in the classroom through the Internet - the convenience and economy of time.

Figure 1 shows that traditional system is still preferred by UKF students too. Students were asked to explain their choice and the analysis of their responses revealed that traditional system has instant feedback for student's misunderstandings, face to face contact, direct interaction, paper is better than monitor, customs from secondary school,

hearing is better than reading; and electronic system is comfortable, modern, less time-consuming, accessible everywhere.

## Internet access

We will present some data related to access to Internet. The results showed that 93% of surveyed DSTU students have access to the Internet, while 78% use it every day, 16% - all the time (during the day), 4% - every week and 2% - every month. The data suggest that 48% of students have the opportunity to use the computer labs, software and Internet at the university after school, 36% - do not have such needs and only 16% of respondents said that they do not have access at all.

What concerns the access to Internet for UKF students – all UKF students have access to the Internet, while 74% use it every day and 25% use it even constantly. Almost all students have access at home, 22% used the access at the dormitory and 26% used hot-spot. Students' distribution according to the objective that they use it most frequently is shown in Figure 2. It's positively surprising that respondents use Internet mostly with the aim to search for course material or to advance their own knowledge (74%), to contact friends (69%), to develop their interests and hobbies (53%), for entertainment (57%), to participate in e-learning courses (44%) and only 29% for file sharing or information exchange.

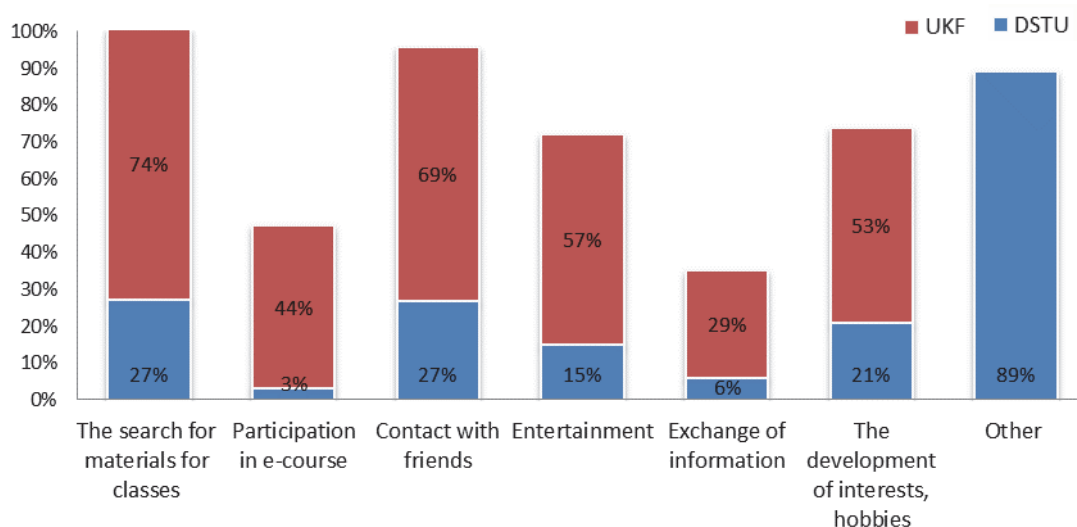


Figure 2: The percentage of students according to their motivation for Internet use.

The answers regarding the objectives of using the web are stated in Fig. 2, which shows that the most popular goal of DSTU students is to search for materials for classes and deepening knowledge (27%). As for the use of the internet to participate in distance courses, we found only 3% of answers. This low percentage of learners who use remote access to educational resources again confirms the relevance of e-education in Ukraine.

To prepare for classes, students often use public (free) Internet resources - 25.82%; educational portals web - 18.36%; contributions received from teacher - 16.91% and electronic resources of the University Library (15.09%).

The data indicate the fact that the popularity of using the Internet not only as an entertainment tool but also as a means to enhance their intellectual and educational level

increases. In comparison, traditional university library resources are not used at the level as it was at least 5 - 10 years ago.

## Educational materials

UKF students use during self-study digital libraries sources (63%), educational portals (61%) and material provided by the lecturers (59%) follows by free open sources (58%). Less often they use materials social networks (48%) and from traditional libraries sources (30%). The smallest percentage of the respondents paid for study materials in the scientific database (7%). E-resources that students prefer to use as a source of educational materials are as follows (Fig. 3).

Despite such significant popularity of search engines the average quality of their information received from them did not exceed 4 within the five-point system, and only 32% of students rated the quality of information from search engines the highest score.

Most of the UKF students prefer search engines to looking for study materials on The Internet. Wikipedia, reliable portals and references to other sites are used very often too. Students rarely used blogs.

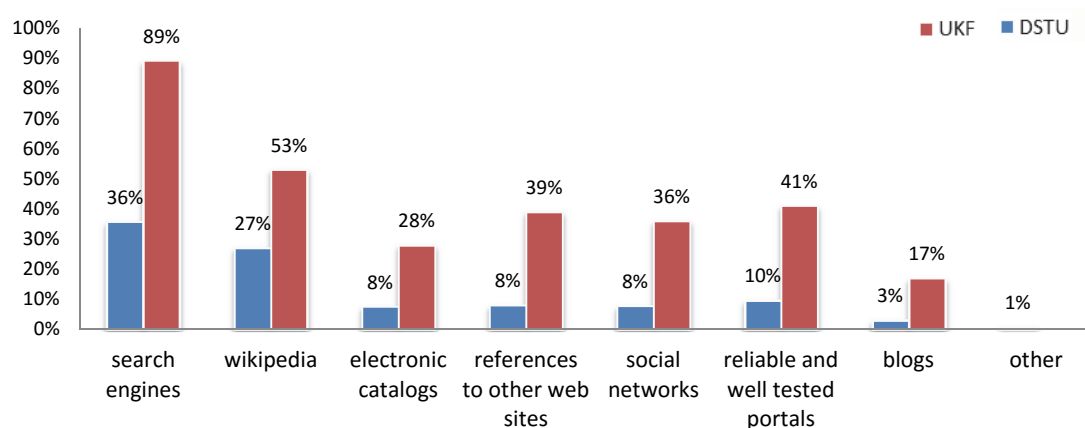


Figure 3: The use of Internet resources in the search for educational materials.

DSTU students claim that Wikipedia is the most trustworthy source owing to evident cognitive and semantic value of its materials; it gained the maximum of 5 points within the 5-grade rating system from the overwhelming majority of respondents - 53% (Fig. 4). The respondents gave 4 points to the materials found on search engines (42%) and materials contained in public PDF files (34%), 3 points were given to file-sharing sites (40%) and papers, multimedia presentations, scenarios published by other users (35%).

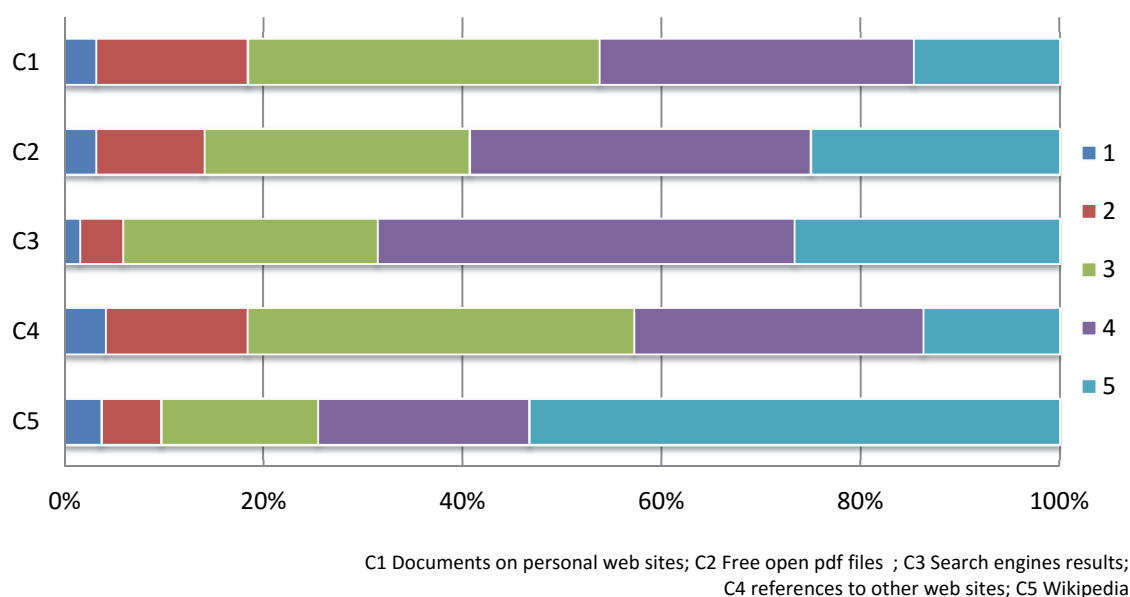


Figure 4: The assessment of cognitive and potential of materials published online at DSTU.

Regarding the perception and attitude of students to gaining knowledge within the e-learning system, we should emphasize the following. At present DSTU does not use distance or e-learning platforms, but most of the students gave clearly approving answers to the question of whether Web technologies are useful instruments for achieving educational goals and accessing training materials on specific subjects (54%). Among them, 27% of students believe that classes in distance mode should take up to 30% of all classes and 21% said they need more of these sessions - from 30% to 60%.

UKF Students also assessed the cognitive value of different kind of resources. They marked the value in the scale from 1 (the smallest value) to 5 (the highest value). There is not such a big difference in the answers (Fig. 5). Free open pdf files are considered to be the most valuable materials, followed by documents (multimedia, presentation, scenarios) published by other authors on their web pages. References to other websites are considered to be the less valuable resources.

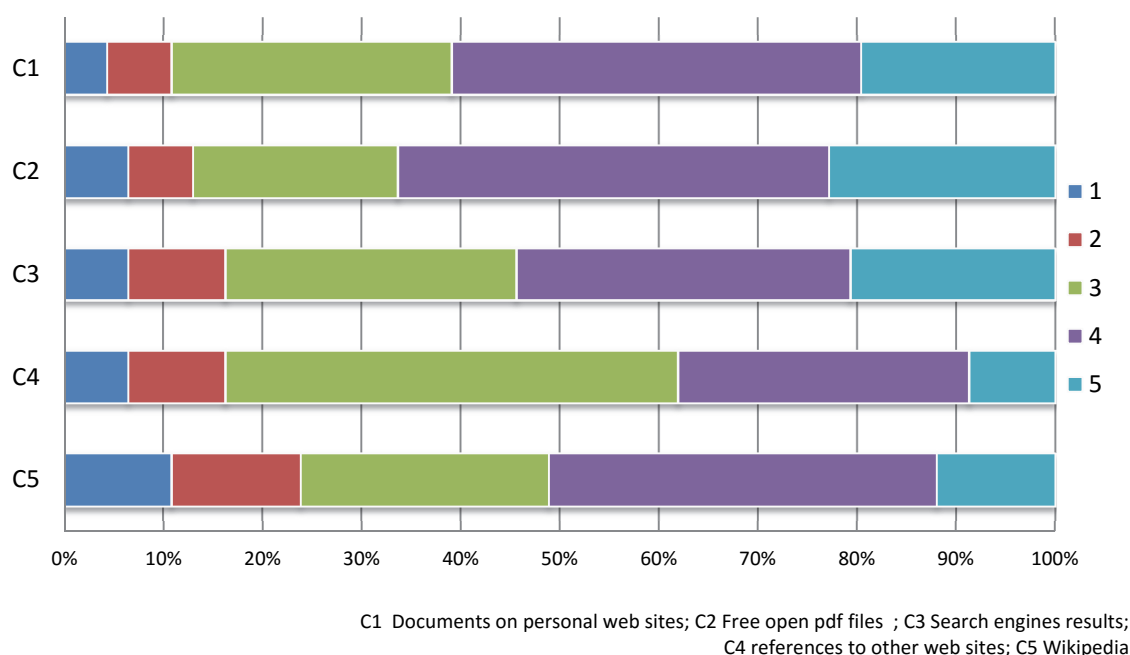


Figure 5: The assessment of cognitive and potential of materials published online at UKF

## Distance learning platform

The management of students' activities in UKF is different in the secondary school and the university. Answers showed that 54% of students know that secondary school has its own school web page, and only 8% said that it does not. Previous experience with distance learning platform in their secondary school had only 2% students, 63% of them didn't have a platform and 35% of them said that they didn't know about it. 89% of students knew that the faculty is used LMS Moodle. Only 6% of the students would prefer to attend all classes in online distance form. The most proposed amount was from 30% to 60% of distance classes per semester (40% of students). Almost 87% stated that the distance learning system can be useful for people with disabilities.

The survey revealed that the best course is a course in which students can find not only educational materials but also control tests (35.76%). Along with this, a large number of positive opinions expressed about the courses supporting all phases of the study (31.25%). The data let us predict that with the introduction of e-learning elements in DSTU the least popular will be the courses that constitute a database of educational materials (21.88%) and forum courses (11.11%).

Students were also asked which mode of learning they prefer: personalized, traditional authoritarian work, authoritarian remote or group remote mode. The answers to this question revealed that despite the willingness to participate in distance learning courses and find resources for this, 55% DSTU students prefer traditional authoritarian work. Personalized form was preferable by 26% of students and group work only 15%. As to the UKF results, only 16% of respondents prefer personalized form of learning while the rest voted for the collective form of education. Only 12% answered that collective work is better in virtual form.

## Communication

An important step in our survey was to uncover students' opinions of the mode and aspects of their contacts with teachers. In particular, we found that currently DSTU students contact with their teachers outside of school hours personally - 31.31%, via email - 29.63%, via phone - 22.56%, through social networks - 15.15 and through distance learning platform only 1.35%.

Outside the classroom, UKF students communicate with teachers usually by email (96%) and personal (52%), rarely using social networks (4%) and mobile phones (7%). The most surprised is that even student can use distance platform system, only 10% of students is familiar to communicate using Moodle. However, effective ways of handling in test papers were found. In addition, we compared them with those currently used (Fig 5.).

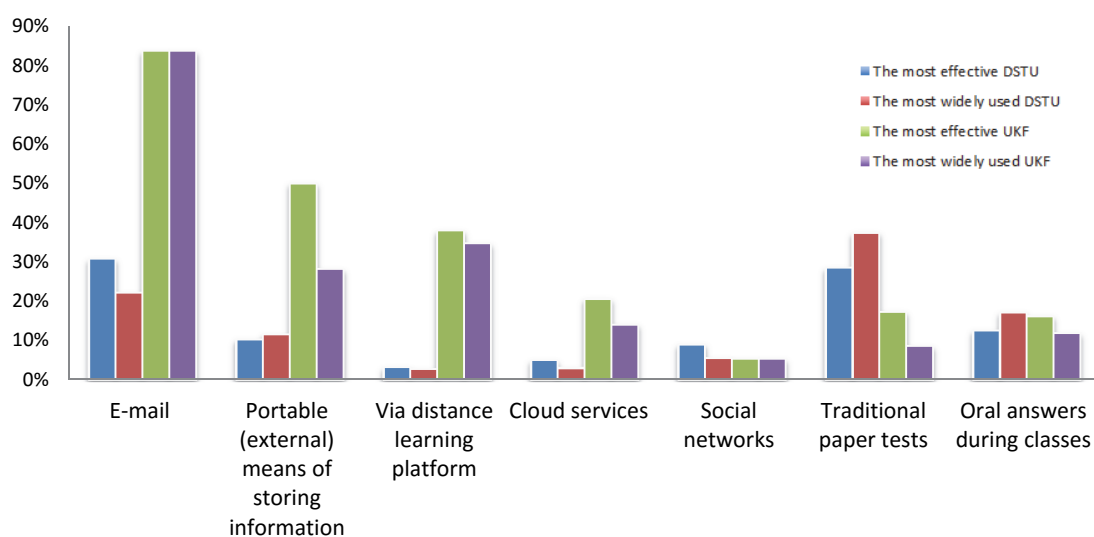


Figure 5: Comparison of the most effective ways to hand in test papers with currently used ones

The students were asked what methods of transmission of their final work (bachelor or master theses) to the lecturer are considered most effective and what kind of transmission is used. We found out that UKF students are considering the email to be the most effective and all of them even use it. Personal transmitting by portable data storage is suitable for 50% students but only a few of them really use it. Cloud services are still almost unused (14%); printed version is use only by 9% of student use it. LMS Moodle is considered to be the most effective for 38% of students and almost each of them used it.

We found out that UKF students are considering the email to be the most effective and all of them even use it. Personal transmitting by portable data storage is suitable for 50% students but only a few of them really use it. Cloud services are still almost unused (14%); printed version is use only by 9% of student. LMS Moodle is considered to be the most effective for 38% of students and almost each of them used it.

The most of the DSTU students believe that email is effective, but in practice, only 22.22% of the students use it. Portable data storage is suitable for 12% of students and cloud services even only 5% of students. More like 37% used printed form. Only 3% of students responded that data transmission via distance learning platforms are effective.

## **CONCLUSION**

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According to the study, the overall conclusion is that DSTU students expressed positive comments about implementing e-learning in the traditional educational system. The findings confirm the need to intensify reforms in the Ukrainian education system aimed at developing distance learning, thus accelerate the integration of Ukraine into the international educational and scientific space. The findings confirm the need to intensify reforms in the Ukrainian education system aimed at developing distance learning, thus accelerate the integration of Ukraine into the international educational and scientific space. The overall conclusion is that UKF student's attitudes and expectations are more positive. We supposed that active using of virtual learning environment from the first class is one of the reasons of these attitudes.

It was established that today students do not have sufficient knowledge about the advantages and positive aspects of e-learning and are accustomed to traditional forms, which they prefer. Therefore, there is a need to widen both students' and teachers' awareness of benefits of e-learning, which are low cost, lack of geographical and time constraints, extensive use of multimedia and information and communication technology, academic mobility, a wide range of controls and ease of updating content of training materials.

Overall, students from both universities feel positively about e-learning in their university. They have also similar attitude to oral answers during classes which means that psychologically it is important for both groups to have real-time contact with their tutor. It should be stress that the other common trait is that students from both control groups share quite low level of interest in social networks – this apparently means that for different reasons the potential of social networks remains poorly applied.

## **ACKNOWLEDGEMENT**

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The research leading to these results has received, within the framework of the IRNet project, funding from the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Programme FP7/2007-2013/ under REA grant agreement No: PIRSES-GA-2013-612536.

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# Teachers' Competencies in Cyber Bullying Prevention Strategies at Primary School

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## Abstract

*The study investigates the influence of teacher competence on cyber bullying prevention strategies at primary school and achievement in skills to create training needs in order to develop teachers' vocational and pedagogical competences as well as competences relating to prevention and supporting co-operation and to the parents community. Schools should not be separated from the community where students are coming from to do better work with youth at school and eliminate different pathological manners. Second part of this study investigates the extent of pupils' experience of cyber bullying. A survey study of 152 students from primary schools and 40 teachers was conducted. In this paper, 'cyber bullying' refers to bullying via electronic communication tools. The teachers refers experiences with prevention programmes in cyber bullying at primary school. The results show that close to half of the pupils were bully victims and about one in five had been cyber-bullied. More than half of the pupils reported that they knew someone being cyber bullied and the most of them know the offender personally or have a relationship with him at school or meet him at home.*

## Keywords

*Cyber bullying Prevention strategies. Teachers' Competencies. Prevention at primary school.*

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## INTRODUCTION

The theoretical framework is based on perspectives in which individuals and the school environment influence, and are influenced by each other in a continuous interaction when teacher competences could here be summarized as the ability, to relate oneself both to the expectancies and demands of society, as well as to one's own attitudes and manners.

Ferguson (1991) studied teachers' results on a license test measuring pedagogical skills as well as subject knowledge. They related the result to student achievement and found these variables to be more powerful than class size and school size.

One common indicator of teacher competence is teaching experience. However, according to Wayne and Youngs (2003), the findings regarding experience are difficult to interpret for several reasons. First, experience captures the effect of whether teachers were hired during a shortage or a surplus. Cohorts will have experienced similar

competition, and selection effects are likely to confound effects of experience. Secondly, experience measures capture differences in teacher motivation resulting from time constraints on parents during years when their own children require more attention. Finally, if there are differences in effectiveness between those who leave the profession and those who stay, experience measures would capture those as well. Such differences are probably dynamic, changing with society, globalization and educational trends.

Several studies (Myrberg, Rosen, 2004) have found a positive relationship between teacher experience and student achievement as well as supporting pupils' motivation at learning process and using active learning methods in the way suits both sides.

It is important for everyone in the community to work together to send a unified message against cyber bullying. Conduct assessments in your school to determine how often cyber bullying occurs, where it happens, how students and teachers intervene, and whether your prevention efforts are working at primary school to eliminate pathological manners. It is necessary to build bullying prevention material into the curriculum and school activities, to train teachers and staff on the school's rules and policies and give them the skills to intervene consistently and appropriately (<http://www.stopbullying.gov/prevention/at-school>).

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## **CYBER BULLYING**

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Cyber bullying is a harmful phenomenon in which youth use technology to harass, threaten, humiliate or otherwise hassle their peers. It is officially defined as "willful and repeated harm inflicted through the use of computers, cell phones, and other electronic devices" (Hinduja, S., & Patchin, J., 2009).

The paper shows that schools are not well equipped to deal with cyber bullying issues. Most harmful incidents of cyber bullying occur off campus (Willard, 2008) making it extremely difficult for public schools to discipline a student without crossing the line for their free speech rights (Willard, 2007b). Developing cyber bullying prevention strategies is a challenge for schools. The strategies that adults may perceive to be effective for stopping and preventing cyber bullying may not be the same as the strategies students perceive to be effective.

Online incidents that occur away from school can trigger in school behavior such as school violence (Willard, 2008). Students may come to school angry as a result of conflict situation happened through online communication at social network and can feel frustrated about anonymous cyber bullying. It is common the a student has no awareness what was said about him or her online until he or she comes at school and then there is a big surprise of why others are laughing about him or her. Being upset about a cyber bullying incident while in school can interfere with a student's ability to concentrate on learning while at school (Beran et al., 2007).

The rise in school violence during the years has prompted schools to take action against bullying. Schools have developed programs to address the issues of school violence and bullying. Successful bullying prevention programs focus on changing the school culture to a climate that discourages bullying.

It is estimated that nearly 30% of students are involved in bullying — as victims, perpetrators or both. Studies have found that 15 to 25% of children and youth in the U.S. are bullied and 15 to 20% bully others. Forty-two percent of children and youth have said they have been bullied while online (Cyber Bullying Prevention and Intervention, 2016).

Cyber bullying most often occurs outside of school hours using home computers (Shariff & Hoff, 2007). School officials are often reluctant to take action against students making posts to websites while not in school (Franek, 2006).

The anonymity of the Internet and knowing that they are less likely to be punished for acts taking place off school grounds makes cyber bullying a attractive as kids think they will not be held accountable for their actions (Shariff, 2008).

A study by Berson showed that when teachers, parents, or other caregivers have an ongoing dialogue about cyber activities and monitor adolescents' Internet use there is a "decreased tendency to engage in cyber activities that lead to potential harm" (Berson et al., 2002, p. 51)

The "Protecting Children in the 21st Century Act" of 2008 specifies that schools teach students about "appropriate online behavior, including interacting with other individuals on social networking websites and in chat rooms and cyber bullying awareness and response" (Protecting Children in the 21st Century Act, 2008).

Schools have used Internet safety education as strategy for reducing risky online behavior to protect students from cyber bullying and other forms of cyber harassment (Williard, 2007b). Cyber bullying prevention strategies include incorporating cyber bullying prevention into anti-bullying programs at schools that should be implemented together with setting clear rules and consequences, raising awareness about cyber bullying among pupils, using Internet filters, acceptable user policies and showing students the aspects of criminalize cyber bullying and reporting of incidents for preventing cyber bullying.

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## **METHODS**

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A mixed methods research design first using quantitative data was used in order to explore what cyber bullying policies are being employed by directors at primary school and the level of competencies to do cyber bullying prevention programmes aimed at involving active learning methods among pupils to eliminate bullying and risk behaviour of the youth.

A non-standardized questionnaire, 'School prevention strategies and pupils' experiencing cyber bullying was verified in a pre-research. Questionnaire reliability ranged from 0.58 to 0.7. The questionnaire contains scaled items and open questions focused on teachers' competencies and prevention strategies.

The collected answers are analysed and statistic characteristics are set (mostly median,

quadrille rate, possibly mean, modus etc.); these data are used in following rounds of evaluation (Bílek, 2008). Return rate of questionnaires was 100% due to the fact that the researchers distributed and collected them personally. The collection of data was made in 04-07/2015 including 40 teachers and 152 pupils at primary school.

The research survey was divided into two parts. In part 1 the application was evaluated from the point of pre-defined set of teacher's competencies and preparation in objectives of cyber bullying prevention programme at primary school. Second part was focused pupil's experience with cyber bullying and prevention strategies done at school.

Teachers expressed their opinions on four-level scale yes (1) – rather yes (2) – rather not (3) – not (4), whether the application provides support to reaching learning objectives and effectiveness of prevention programme and to having right competencies:

C1: Personal competences: Teacher is able to solve problems and manage conflicts in class, including the ability to active listening, giving constructive feedback, be aware of their own strength and weaknesses, preferences and dislikes to tackle misunderstandings, to assert one's own concerns and rights, without violating the rights of others, the ability to empathise with feelings of the pupils and understand group needs.

C2: Pedagogical competences: implies that the teacher from definite goals and frameworks, through continuous development of teaching and personal professional development, supports and facilitates the learning of the students in the best way (In Ryegård, 2010).

C3: Management competences: Teachers' ability to do effective classroom management, and quality prevention programme implementation, make healthy teacher-student relationship, to create special learning environment for students with special needs.

C4: Vocational competences: teacher must have the ability and motivation for self-evaluation and reflection. to determine the extent the required learning outcomes, to be able to cooperate in creation learning environment and facilitate learning process in different levels.

The cyber bullying prevention programme under review takes into account the fact that successful educational activity and prevention in school calls for personal competences, as well as management and method-related skills.

In part 2 the experience of cyber bullying was evaluated on the five-level (5) – very good (4) – good (3) – sufficient (2) – low (1) – very low (1). Experience of cyber bullying were included in the view of victim and offender, level of cognition, motivation elements, activation and prevention strategies.

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## **RESULTS**

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Teacher must be competent to establish and lead good relationship with all social partners, to communicate and interact at many different levels and coproduce the learning process with all partners. Linking with colleagues to discuss the trials and challenges of teaching and share instructional strategies can result in solutions that can teachers immediately apply in the classroom, and into development projects for the school.

Table 1 presents data including the teachers' competences needed in learning and teaching process at primary school implementing cyber bullying prevention programme.

Table 1: Correlation between teacher's competences and personal perceptions

Competences / Teacher	Have to teacher and learn	To educate and guide	To evaluate	Have to counsel	Have to innovate
Personal competences	3.245	3.211	3.139	3.405	3.420
Pedagogical competences	3.521	3.195	3.083	3.922	3.901
Management competences	3.214	3.234	3.312	3.344	3.426
Vocational competences	3.218	3.547	3.426	3.320	3.714

Socially and emotionally competent teachers exhibit prosocial values and make responsible decisions based on an assessment of factors including how their decisions may affect themselves and others.

Table 2: Learning methods used by teachers in prevention programme

Methods	Frequencies	Effectiveness
Group work in the class	0.0314	0.020
Presentation about cyber bullying	0.0378	0.0415
Using active learning methods through experience	0.0294	0.0171
Peers prevention programme	0.0314	0.0163
Discussion forum	0.0411	0.0321
Interactive workshops	0.0215	0.0324
Lecturing	0.0408	0.0478
School campaigns against bullying	0.0509	0.0032

Table 2 shows the methods used in prevention programme at primary school and it in the point of view of teachers. They find group work in class with combination of interactive workshops and preventive campaigns with active involvement of students as the best way of elimination pathological manners in school environment. On the other hand, teachers confess that lecturing, presentation and discussion are more often used at schools as the cheapest way of doing preventive programmes not bringing such a positive impact on pupils' behaviour.

Using peer to peer strategies in cyber bullying prevention programme brings positive interaction between pupils and effective way of sharing experience and exchanging opinions. Young people are more likely to listen to people like them, because young people have best knowledge of their lives, situations and contexts, they speak the same language in the same way and identify with the same cultural shorthand.

Table 3: Cyber bullying Prevention strategies in the view of teachers

Strategy Description by teachers	p-value
(1) No access to social networking at school	0.0182
(2) Parents more involved in education and prevention	0.0423
(3) Higher control of students the way of using internet	0.0383
(4) Active involvement of offender to preventive activities about cyber bullying	0.0117
(5) Having written policy on zero toleration about cyber bullying.	0.0162
(6) Having clear rules in each class especially suits to pupils needs	0.0343

In the table 3, the teachers selected the top-6 most effective strategies helping prevention of cyber bullying and raising awareness of its negative aspects in youth life and positive school culture. Teachers prefer active involvement, no access to net in school environment and having written police on zero toleration about cyber bullying as the most positive and effective tools of prevention. The less effective is communication with parents and parental education, because the most of them are not willing to solve this problem and parents expected the school to do more about it.

Table 4 : Students views on cyber bullying prevention strategies

10 Strategies for offender	p-value
1 Doing extra prevention activities due to cyber bullying	0.045
2 Stop using net for offender	0.0203
3 Enforcing penalties on offender.	0.035
4 Offender actively involved in prevention program.	0.018
5 No computers and cell phones for offender.	0.005
6 Stop advantages for offender at school.	0.048
7 Setting clear rules at home and in school environment.	0.017
8 Effective cyber bullying prevention programs including parental education.	0.026
9 Raising awareness of parents and control at home using internet	0.043
10 Better cooperation of school and parents at prevention strategies	0.0312

In the table 4, there are the most effective strategies selected by students on the purpose to find strategies aimed at offenders of cyber bullying and their elimination of risk behavior.

These strategies - strategy 5 (taking away offender's computers and cell phones) and strategy 2 (no access to net connection for offender) are found as the most negative for young people who can't imagine not to be connected with social network, internet or smartphone as nature part of their life.

Students, no matter whether they are offenders or victims, believed that "effective prevention programme" and "parental education and control" are among the top-three strategies that could most effectively prevent cyber bullying. That is a strong message for school directors and parents to make more effort on cooperation with parents to create safe environment for children.

Considering the fact that the three strategies are all penalties to offenders or something against the wills of offenders, the effectiveness of implementing these strategies would be most dependent on offenders' views. However, the correlation directions are all positive, which suggests that offenders tend to view these strategies as ineffective compared to non-offenders.

Offenders often have low school commitment and may not care if they are not allowed to participate in extracurricular activities, as they may not want to participate in these activities in the first place. Hence, strategy 3 Enforcing penalties on offender and strategy 6 Stop advantages for offender at school activities would not be an effective strategy to deter offenders from cyber bullying. Offenders may not perceive cyber bullying to be wrong and would not be embarrassed to give a presentation about it making strategy 1 ineffective.

There are two strategies in Table 5 with negative correlations. They are "setting clear rules and consequences" and "having ongoing cyber bullying prevention programs." The

negative correlation is interpreted as that offenders tend to view the strategies as being more effective than victims. Students who have had experience cyber bullying others tend to view "clear rules" and "ongoing programs" as being more effective than those who have never cyber bullied others.

Compared to strategies 4, 7, and 6 that have positive correlations, strategies, 8 and 9, are general and not specific. It suggests that although cyber bullying offenders may not view the three specific and mild strategies as being effective, they would not consider any rule to be ineffective. Clear rules with penalties enforced and ongoing cyber bullying prevention programs are in general viewed as effective by the offenders. So, when a specific cyber bullying prevention strategy is established, its effectiveness should be accessed carefully and individually (Table 5).

Table 5: Average effectiveness of strategies in the eyes of students

(1=very ineffective, through 5=very effective)

Strategy	pure-victim (n = 44)	pure-offender (n=85)	neither-offender-nor-victim (n=152)
1	3.083	3.242	3.073
2	2.696	2.738	2.746
3	3.367	3.148	3.357
4	3.920	3.221	3.623
5	3.495	3.426	3.419
6	3.592	4.109	4.083
7	3.365	3.426	3.411
8	3.213	3.474	3.245
9	3.592	3.122	3.540
10	3.441	3.932	3.240

The finding is consistent with research that pupils use technology as a link to their friends and social life. No student, regardless of whether they are a pure-offender, pure-victim, or neither-offender-nor-victim, would want to be isolated from their social network online. Parents, schools, and social networking sites all are important stakeholders in preventing cyber bullying (Ybarra et al., 2007).

Hence their cooperation is needed to for that purpose. Policies need to be in place at school, and the school should involve parents when a cyber bullying issue arises. Meanwhile, parents have a responsibility to establish and enforce rules at home. Such a joint work is necessary for effectively resolving the problem of cyber bullying.

### Time spending on social network and experiencing cyber bullying

According to pupils' answers, the average user logs 2.0 hours per day on social platforms, which represents about 32% of all online activity. Micro-blogging, which includes Twitter, Facebook and Instagrams is also up to 0.80 hours per day. In terms of amount of time spent on social media networks, pupils spending the most time per day on their phones with a staggering 3.8 hours.

79% of children between 9-12 age own a smartphone, 56% of them have their own tablet and up to half of them use cell phone to make selfies or videos.



The more time children spending online on surfing on the Internet the more risk is to become victim of cyber bullying and survey data indicate that incidents of cyber bullying are becoming quite common among children at primary school. In a survey of 152 students 31.4% are regarding online bullying and experience with online harassment.

Our study of 152 participants reported that 18% of children had been bullied online; 39% of children had been threatened, 14% had received threatening messages, 61% had mean things said to them, 53% admit to saying something mean to someone online, and 75% did not report it to an adult.

## **DISCUSSION**

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Effective bullying prevention programs have to change the school environment and support healthy peers relationships at school and also outside of school. Cyber bullying prevention programs need to have a similar philosophy and need to empower students to stop cyber bullying themselves. Students do not perceive being told not to cyberbully as changing the school climate. They may find programs that teach them what to do if they are cyber bullied and lose control on offender.

Prior research by Harris Research for the National Crime Prevention Council revealed that 47% of teenagers thought that "cyber bullying happens because the cyberbully doesn't perceive any tangible consequences" (Moessner, 2007, p. 3) and 45% thought it "happens because the teen think she or she won't get caught" (Moessner, 2007, p. 3). That research also found that teens perceived the most effective strategies to be "blocking people online who bully, refusing to pass along cyber bullying messages and online groups having moderators who block offensive messages as being the most effective" (Moessner, 2007, p. 4). Strategies that were perceived as less effective were "all schools should have rules against cyber bullying; schools should educate students in small groups not to cyberbully, holding school assemblies to educate students not to cyberbully, and teaching adults to help young people not to cyberbully," (Moessner, 2007, p. 4)

Baková (2015) points, that cyber bullying brings negative aspect to persons' personal development and can lasts a long time to avoid offender's attacks. Children who are targeted by cyber bullying display negative reactions that are similar to those of children who are victims of traditional bullying.

Cyber bullying can be more devastating than traditional forms of bullying due to the much larger audience online (Strom & Strom, 2005) and because children now cannot even escape their bullies by going home to a safe environment (McClung, 2006).

Cyber bullying has been linked to multiple maladaptive emotional, psychological, and behavioral outcomes (Hinduja & Patchin, 2009). The physical and mental effects of cyber bullying vary depending on the victim, but the consequences include low self-esteem, anxiety, feeling sad, being scared, feeling embarrassed, depression, anger, truancy, decreased academic achievement, an increased tendency to violate others, school violence, and suicide (Willard, 2006; Beran & Li, 2005).

Not all victims of cyber bullying report serious effects, but according to one study, 34% of cyber bullying victims felt frustrated, over 30% felt angry, and nearly 22% felt sad (Patchin and Hinduja, 2006). Although these behaviors don't initially occur at school, their

emotional effects often accompany students when they do come to school. Because these emotions can lead to increases in violence, increases in truancy, and decreased academic performance (Beran & Li, 2005), schools have a invested interest in dealing with issues related to cyberbullying.

Children in middle school often fail to report bullying behaviors because they believe that it will not solve the problem (Cannon, Hayward, & Gowen, 2001). This may be attributed to the perception of many children who believe that bullying behaviors are often tolerated or ignored by school officials (Peterson & Skiba, 2001), or to the fact that teachers rarely detect or intervene in incidents bullying (Skiba & Fontanini, 2001) despite the fact that bullying often takes place right in the classroom (In Wiseman, 2011).

## **CONCLUSION**

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Cyber bullying is alarm problem that should be eliminated at school environment as well as teachers should be trained to create and develop flexible and innovative prevention programme for individuals and groups based on strategies agent bullying and online harassment. Teachers are expected to be able in finding new ways in which prevention programme can be facilitated and to construct intellectually challenging, inclusive and participatory learning experiences that connect with the psychological intervention and supervision. It is important in realisation of prevention programmes at schools to eliminate risk behaviour in learning environment and to take part in parents control.

Pedagogical knowledge including knowledge of learning, teaching methods and curriculum have more often been found to influence teaching performance, and frequently these factors exert even stronger effects than subject matter knowledge. Teachers have to use specific methods based on active learning techniques to prevent cyber bullying and to form prosocial behaviour between pupils.

Research showed strong relation to teachers' quality of methods and efficiency of prevention programme. It is necessary to choose right active learning methods suits to age, mental development and large of group to achieve good results in prevention strategies among pupils. In a study involving 40 teachers and 152 pupils found that the quality of the prevention programme has a comparable impact on students' manner and elimination of risk behaviour in school environment.

Teacher must have the ability to make healthy relationship with pupils in the case to solve different serious situations and problems. Teacher is supposed to be autonomous and confident expert who is playing proactive role in school field. He is also supposed to be communicative, sensible and motivated enough to observe and lead constructive dialogue with his students in purpose to find best options for supporting their personal development and support children protection against violence and bullying.

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# Distance Learning of Applied Informatics

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## **Abstract**

*Distance learning uses computer resources at present. E-learning is a popular way of dealing with distance learning. This brings new opportunities, methods and forms. Computer equipment and appropriate educational software allow you to improve the quality of distance learning. Information and communication technology brings not only new possibilities in human life, but also a new approach to education. Nowadays, it is important for us to make management of information and communication technologies to a higher level in comparison with the past. Recent results indicate that distance teaching is less successful than the full-time teaching. The paper shows the practical experiences of distance learning at the Department of Informatics and Computers at the University of Ostrava. The paper compares the results and success of distance students and full-time students in various semesters of Bachelor's degree program Applied Informatics. It was also utilized the method of questionnaire and pedagogical experiment. The aim was to show how distance students and full-time students use different parts of LMS Moodle. The author shows the basic problems, difficulties and practical experience with these forms and its specifics in teaching of informatics.*

## **Keywords**

*Distance education. E-learning. Informatics. LMS. T-test.*

## **INTRODUCTION**

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Department of Informatics and Computers and the University of Ostrava introduced distance learning teaching using e-learning methods in the academic year 1998/99, and in bachelor study program Applied Informatics. The main goal was to offer the opportunity to study hearing impaired candidates. The interest in this form of study soon showed also students without disability. Currently in the first year of undergraduate study received around a hundred students combined and distance forms. Department of Computer Science offers distance e-learning in the master study. The most important problem lies in abilities of students to manage their studies. Part of students is unable to plan well-proportioned schedule for learning. They often start to learn at the end of semester before course exam. They are requested to finish successfully several courses and that why they don't have enough time to complete all course requirements and often they fail in the whole study (Van de Vord, 2010) (Klímová 2015).

## THE COMPARISON OF DISTANCE AND FULL-TIME STUDY

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It turns that distance learning is difficult for the students. The most important problem lies in abilities of students to manage their studies. Part of students is unable to plan well-proportioned schedule for learning. They often start to learn at the end of semester before course exam. They are requested to finish successfully several courses and that why they don't have enough time to complete all course requirements and often they fail in the whole study (McPhee, 2012). First semester of a study is the most problematic period of studies. There are many such students that interrupt their studies on this period. One of the reasons is bad information and incorrect idea about the distance learning (Levy, 2007).

### The methodology

We used the method of questionnaire and pedagogical experiment. We want using the results of research to determine whether students' test results are dependent on distance or full-time study. Students completed a paper version of the questionnaire, which contained 8 questions and 2 tasks. The questionnaire contained content items, but also functional items, specifically items contact and control. Most of the items of the questionnaire were closed or semi-closed structured entries. Questionnaires were sent out, but the individual respondents were personally sought to fill, to ensure a full return. The evaluation of the data obtained were used statistical methods (Chráska, 2007). For analysis of the results in each item was measured as having detected data variability. We used a coefficient of variation. To interpret the results of the second stage classification was done t-test. For evaluating the results were used MS Excel and statistical software Wizard for the operating system Mac OS X and statistical software Statistics Visualizer for iPad (Řehák, Brom, 2015).

Parts of the questionnaire were two practical tasks. The first task was to comment code in language Swift. This language is partly based on the C language and the student is not yet acquainted with him. The second task was to rewrite the code from language Swift to language C. Students could get for each task 0 to 10 points.

We compared the results of students in courses. We used statistical methods. For comparison, the results of the two groups (distance and full-time students), we used the T-test: Two-Sample Assuming Equal Variances. Two sample t-test is used to compare the difference of two populations. This parametric test assumes that the variances are the same in both groups. This assumption we tested by the F-Test Two-Sample for Variances.

We have set up two hypotheses that describe study results in programming courses:

H1 - Distant students have worse study results than full-time students.

H2 - Distance students have less practical skills in designing programs than full-time students.

### The result of research

The questionnaire was completed and the experiment was attended by 35 students. Respondents studied bachelor program Applied Informatics. Distant students were 8, of which 63% were men and women were 38%. Their average age was 39 years. Full-time students were 27, their average age was 21 years. 89% were men and women were 11%.

Distance students had an average attendance of 94%. Full-time students had a 78% participation in present education.

We compared the results of a student who solved practical tasks in languages Swift and C. For evaluation we used F-Test Two-Sample for Variances and T-test: Two-Sample Assuming Equal Variances. The results show that we can not reject the null hypothesis. Hypothesis number two is unproven. Both groups had similar results.

The next chart shows the average evaluation as student used certain parts of online courses in LMS Moodle. (1 = I did not use, 2 = helped a little, 3 = moderately helpful, 4 = most helped me). Evaluation of both groups are almost identical. They differ only in the use of video lectures and correspondence tasks. This result was expected.

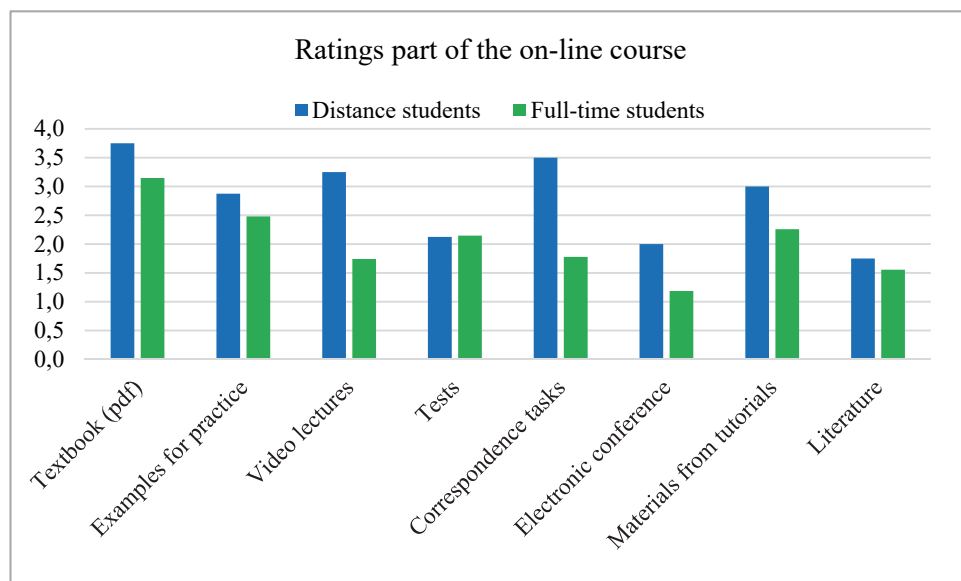


Figure 1. Ratings part of the on-line course.

On the next graph shows the frequency of individual student work. Students answered how often they create their own programs. Students who chose a different frequency, usually only programmed before the test or before submitting correspondence task. In both groups it is seen very small frequency independent creation programs.



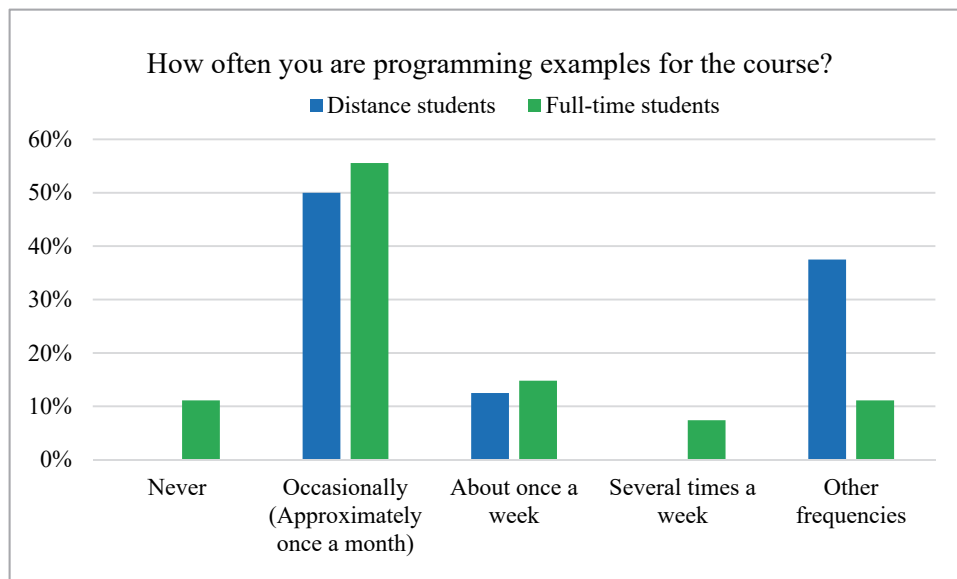


Figure 2. How often you are programming examples for the course?

The following part of the paper describes the comparison of results of full-time students and distance students. Distance learning puts students at much higher demands than studying full-time. This is reflected in the results of the students. We can observe the differences between the group of distance learners and a group of full-time students. The difference is mainly in the first semester. The success rate of full-time students is 64% in the first semester. The success of distance learners is only 39% in the first semester.

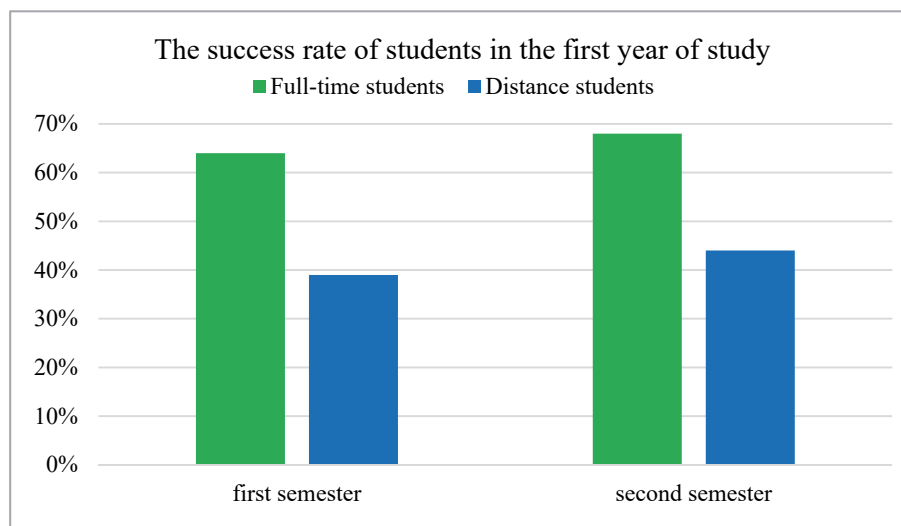


Figure 3. The success rate of students in the first year

The following chart shows a comparison of the success of distance students and full-time students in course Computer architecture and Fundamentals of operating systems. Students usually study this course in the first semester. Results show differences in the past six academic years. The graph shows that the results of distance learners are worse than those full-time students.

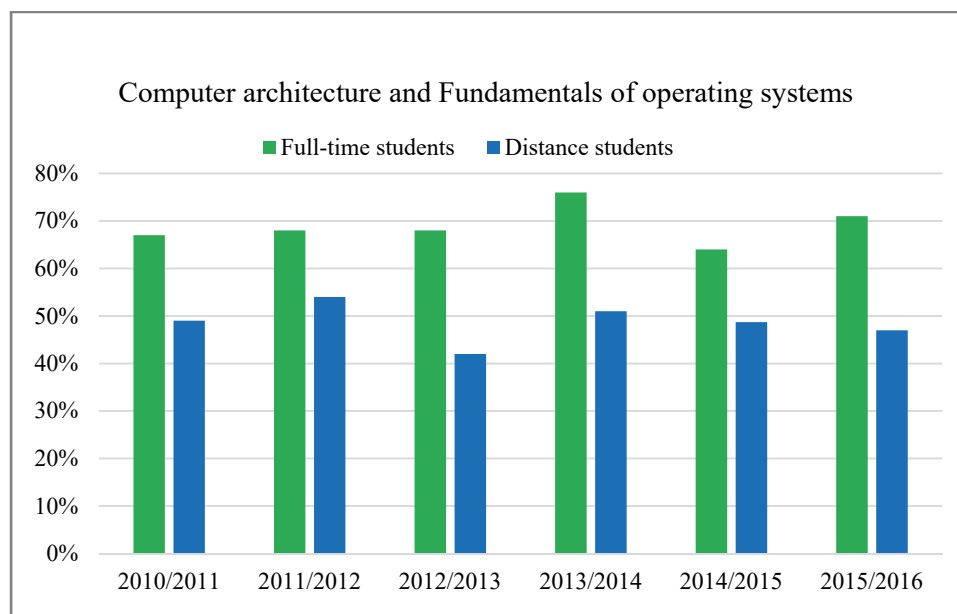


Figure 4. The average of successful students in course Computer architecture and Fundamentals of operating systems (typically first semester)

The next graph shows the percentage of students in course Programming in C++. Students typically study in this course in the fourth semester. The average of successful students in distance learning is 69% and in full-time study is almost 76%. Differences between the two groups are not so pronounced. Distance students in higher semesters are more successful study and do better organize and manage.

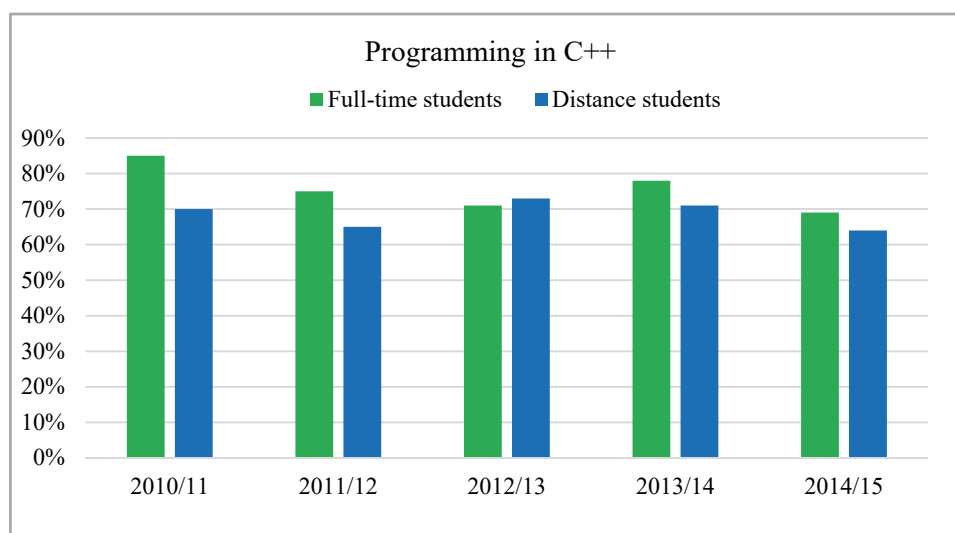


Figure 5. The average of successful students in course Programming in C++ (typically fourth semester)

The following graphs show the results of students in courses in 2015. We've compared the results in courses: Basics of programming (typically first semester), Architecture of hardware and Fundamentals of operating systems (typically first semester), Programming in C (typically third semester) and Object-Oriented Programming (typically third semester). Each student can receive a maximum of 100 points. For the success of the course, he must gain at least 51 points.

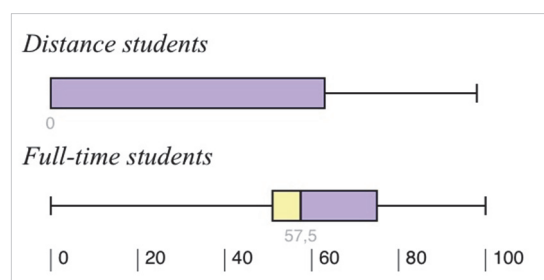


Figure 6. Successful students in course Basics of programming

First, we conducted F-test that we ensure that the variances in the two groups are identical. The test showed the great diversity of variances, so we made t-Test: Two-Sample Assuming Unequal Variances. The course Basics of programming: we can reject the null hypothesis based on the results in the table. The average number of full-time students are points higher than for distance learners. The results of course show that we reject the null hypothesis. Distant students had worse results than full-time students.

Table 1. t-Test: Two-Sample Assuming Unequal Variances for course Basics of programming

t-Test: Two-Sample Assuming Unequal Variances	Distance students	Full-time students
Mean	28,06	54,83
Variance	1366,06	829,06
Observations (number of students)	52	66
P(T<=t) one-tail	0,00002	
t Critical one-tail	1,66123	
P(T<=t) two-tail	0,00004	
t Critical two-tail	1,98552	

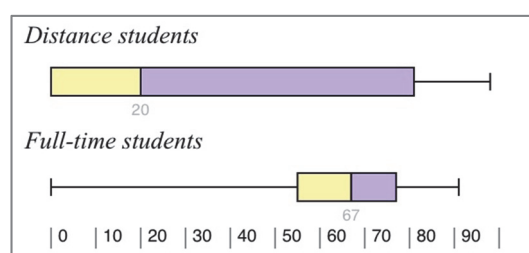


Figure 7. Successful students in course Architecture of hardware and Fundamentals of operating systems

For courses Architecture of hardware and Fundamentals of operating systems, Programming in C and Object-Oriented Programming F-test confirmed compliance variances. Therefore, was further carried t-Test: Two-Sample Assuming Equal Variances. The results in table number two shows that we must reject the null hypothesis. Distant students had worse results than full-time students.

Table 2. t-Test: Two-Sample Assuming Equal Variances for course Architecture of hardware and Fundamentals of operating systems

t-Test: Two-Sample Assuming Equal Variances	Distance students	Full-time students
Mean	39,05	54,95
Variance	1643,70	1020,12
Observations (number of students)	76	94
P(T<=t) one-tail	0,00239	
t Critical one-tail	1,65397	
P(T<=t) two-tail	0,00478	
t Critical two-tail	1,97419	

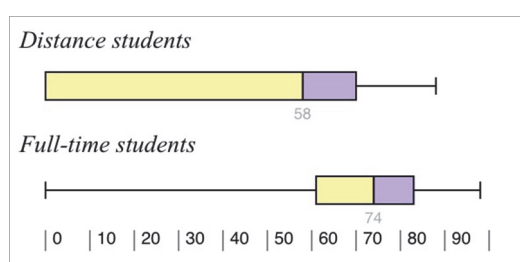


Figure 8. Successful students in course Programming in C

The course Programming in C: the results show that we reject the null hypothesis. Full-time students had better results than the distance students. In the group of distance learners is the part that received zero or very few points. A large part of distance learners not completed the course.

Table 3. t-Test: Two-Sample Assuming Equal Variances for course Programming in C

t-Test: Two-Sample Assuming Equal Variance	Distance students	Full-time students
Mean	42,84	66,75
Variance	1187,25	702,71
Observations (number of students)	19	36
P(T<=t) one-tail	0,00300	
t Critical one-tail	1,67412	
P(T<=t) two-tail	0,00600	
t Critical two-tail	2,00575	

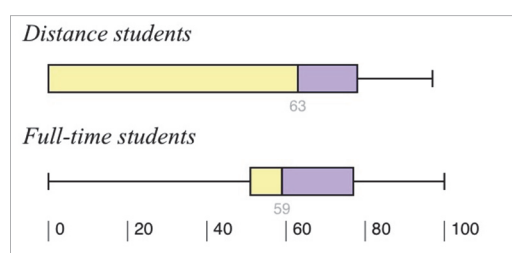


Figure 9. Successful students in course Object-oriented Programming

The course Object-oriented Programming: the results show that it is confirmed null hypothesis. Full-time students had about the same results as distance students. But in the group of the spacer it is also part of students who acquired zero or very few points.

Table 4. t-Test: Two-Sample Assuming Equal Variances for course Object-Oriented Programming

t-Test: Two-Sample Assuming Equal Variances	Distance students	Full-time students
Mean	45,79	54,93
Variance	1421,21	880,62
Observations (number of students)	28	55
P(T<=t) one-tail	0,12	
t Critical one-tail	1,66	
P(T<=t) two-tail	0,23	
t Critical two-tail	1,99	

Previous results demonstrate the veracity of the hypothesis H1. At the beginning of their studies, distance students have the significantly worse results than full-time students. A large part of distance students not complete successfully the first year of study.

The survey shows that it is necessary to focus more on distance students in the first year. It is not enough just to prepare study materials. Multimedia and interactive materials can facilitate self. Experience shows that it is necessary to motivate students to regular work. We can achieve more frequent correspondent assignments, tests and projects (Cavanaugh, Gillan 2004).

## CONCLUSION

Distance learning brings new problems. The research results show that distance students have worse outcomes than full-time students. Students, especially in the first years of distance learning have significantly poorer success rate than full-time students. Many distance students in the first semester will not come to the exam. It is therefore necessary to improve the quality of studies, offer a quality learning materials and ensure good governance study. To a considerable degree of improvement contributes use electronic conference rate and increase students' activity during the semester. It is advisable to insert solved examples, video tutorials and video lectures into online courses. The most important problem lies in abilities of students to manage their studies. Part

of students is unable to plan well-proportioned schedule for learning. They often start to learn at the end of semester before course exam. They are requested to finish successfully several courses and that why they don't have enough time to complete all course requirements and often they fail in the whole study. Nearly 60% of the distance students do not successfully complete the first year. Full-time students are more successful. 66% of full-time students successfully completing the courses. Differences between the groups are small in subsequent semesters.

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# Contributing Student Learning with the Peerwise Tool at the Matej Bel University

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## Abstract

*Contributing student pedagogy requires students to produce artifacts (contributions) for the purpose of contributing to other peers' learning, and encourages students to value these peer contributions. A free web-based tool called PeerWise was created by Paul Denny at the University of Auckland to provide support for the implementation of contributing student pedagogy. It supports the authoring of multiple choice questions that other students can use and provide feedback on. A lot of institutions throughout the world use PeerWise. This paper describes case studies of various approaches to the use of the PeerWise system within 8 computer science courses taught by 3 teachers at the Matej Bel University (Introduction to Informatics, Semestral Project, Database Systems and Multimedia courses). We successfully used this system in 7 courses. The system was used by 273 students during 2 academic years (from summer semester 2014 until winter semester 2015). We used it as a presentation tool, motivation tool, learning tool for preparing for exams, exploring tool for understanding the design of this system for educational purposes. Our students like to use this system if they see the benefit of it for their learning and for passing the courses. So this is a task for their teachers to better understand the possibilities of the system and to motivate themselves to effectively use this system in their courses.*

## Keywords

*Collaborative learning. Interactive learning environments. Computer science education. Contributing Student Pedagogy. PeerWise.*

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## INTRODUCTION

In this paper we would like to introduce our experience with a collaborative tool for creating multiple-choice questions by students. This web-based interactive learning environment called PeerWise was created at the University of Auckland by Paul Denny (Denny, n.d.; Denny, Luxton-Reilly and Hamer, 2008a). This collaborative learning environment was developed with an aim to help students better understand and learn key concepts or useful content of a subject. PeerWise supports students in the creation, sharing, evaluation and discussion of assessment questions. It is widely and successfully used by more than 1500 universities, schools and technical institutes from around the world (The University of Auckland, 2016a).



Since 2008, there has been a lot of evidence about usefulness and success of the PeerWise system around the world (The University of Auckland, 2016b). Inspired by this, we began to use the tool in our institution in bachelor study programmes of Applied Informatics, and Teacher Training in Informatics at the Department of Computer Science in 2014. Since then we have gained some experience from 8 computer science courses which used PeerWise to support contributing student learning. We wanted to explore how this system can be used in our courses. The second reason for the use of PeerWise in our courses was to introduce it as a software educational tool to our students, some of whom are future software designers and could find this experience beneficial in terms of their careers.

## **BACKGROUND AND MOTIVATION**

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Effective learning means achieving its objectives with the least effort in a short time. It is characterized by activation, motivation, autonomy and creativity of students. The aim of students' activity is the acquisition of new knowledge and its application in practice. Activation means (Škrinářová, 2011a) arousing, directing student activities at work, in line with the objectives of education. Repeating questions and answers is one of the basic methods of activating students by a teacher. Students also can be activated when they create and formulate various tasks for their peers.

According to Aberšek and Aberšek (2012), e-learning tools suitable for design and methodology in the context of constructing student's mental model are important. A lot of research in education is concerned with the development of intelligent applications (Dolenc, Aberšek and Aberšek, 2014) such as Intelligent Computer Aided Instruction (CAI), Intelligent Tutoring System (ITS) and Intelligent Learning Environment (ILE) and also with applications that can be justified as being consistent with educational theories.

The life cycle of courses in which different levels of feedback are included (Škrinářová, Horváthová and Gubalová, 2013) is important for achieving educational objectives. Individualized concepts in accordance with construct approach evaluated on specific training activities (Lovászová and Palmářová, 2012), (Škrinářová and Krnáč, 2011b) show the different types of social interactions which use the online environment. Although students work on individual basis, online communication creates stimulating social context for their activity.

PeerWise is a web-based system that can help as a tool for Contributing Student Learning (Hamer, et al., 2010). A Contributing Student Pedagogy (CSP) has been defined by Hamer, et al. (2008, p.195) as a "pedagogy that encourages students to contribute to the learning of others and to value the contributions of others." The roles and responsibilities of 'teacher' and 'student' in learning processes found in industry and research are fluid, so one motivation for the use of the CSP approach in formal education is to prepare students for this shift.

Student contributions (e.g. created tutorial materials, demonstrations, worked examples, examination questions, provided feedback) in CSP have to (a) contribute to the learning of other students and (b) be valued by other students. This approach is linked to constructivist and community theories of learning. It provides opportunities to engage students more deeply in subject material (Hamer, et al., 2008).

Hamer, et al. (2010) realized that CSP as defined above may happen accidentally – e.g. if students “informally share and discuss their draft assignments with friends ... this is unintentional collaborative learning, and not part of the instructor’s explicit pedagogical design.” Therefore they specified CSP (for the purposes of describing and evaluating tools for “contributing student learning”) only as an intentional collaborative learning: They took into account only both (1) the explicit intention of the instructor (in defining learning activities) and (2) the intended audience for the contribution (students are aware that their contributions will be used by other students). So they defined CSP (a narrower definition) as a “pedagogy that requires students to produce artifacts for the purpose of contributing to other students’ learning, and encourages students to value these peer contributions.”

A web-based system called PeerWise (The University of Auckland, 2016a) is one example of a software tool which provides support for the implementation of a CSP (Denny, Luxton-Reilly and Hamer, 2008a; Paterson, Wilson and Leimich, 2010). This web-based tool supports the authoring of multiple choice questions (MCQs) that other students can use and provide feedback on (Hamer, et al., 2010). Students themselves can create an online repository of MCQs, answer questions contributed by others, and evaluate other students’ contributions. Denny, et al. (2008b) assert that if students are asked to write MCQs together with providing appropriate explanations, this gives them a richer and deeper learning experience than simply answering practice questions provided by a teacher. Because some questions or their parts can be poorly designed (e.g. a text of a question, offer of distractors, correct answer, correct explanation, tags), the PeerWise system also gives students an opportunity to develop their skills in critical thinking and evaluation.

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## **EXPERIENCE AND RESULTS AT THE MATEJ BEL UNIVERSITY**

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In this section we present case studies of using the PeerWise system at the Matej Bel University (PeerWise Matej Bel University, 2016) in 8 computer science courses taught by 3 teachers (see Table 1, part teachers). Until summer 2015, PeerWise had been more widely used by 1 teacher in 6 courses (semestral project courses and database systems courses; Table1, T1). This teacher introduced her experience and results to other colleagues of our department in November 2014 and November 2015 during “The week of science and technics”. At the end of winter semester in 2014, one other teacher started to explore this tool with her teacher training students within a multimedia course (teacher T2 from Table 1). After this experience and influenced by Denny (2015) she and another one colleague decided to use PeerWise in their 2 courses (Multimedia, Introduction to Informatics; Table 1, teachers T2 and T3) as a pilot study in winter semester 2015. Syllabi of these courses can be found at the Faculty of Natural Sciences websites (Fakulta prírodných vied UMB, 2015). Table 1 shows an overview of basic facts about our use of PeerWise in these courses and results obtained (participation summary and number of questions, answers and comments created, average count of these contributions per student).

### **The use of PeerWise in the Database Systems and Semestral Project courses**

We mentioned our first experience with the use of PeerWise system as a tool for supporting mastery learning in an introductory programming course (Jacková, 2013;

Jacková and Denny, 2014). Our pilot study and results of the use of PeerWise in the Semestral Project 2 and the Database Systems 2 courses in summer semester of 2014 (Table 1, courses No1, No2) was introduced in Jacková and Denny (2014) and Jacková (2014; 2015). Next academic year 2014/2015 we continued with exploring possibilities of this system in other 4 courses – Semestral Project 1, Database Systems 1 and the second run of Semestral Project 2 and Database Systems 2 courses (Table 1, courses No3-No6).

Table 1: The use of PeerWise in computer science courses at the Matej Bel University.

SUBJECT			TEACHERS (T)			STUDENTS		average count per student			
name grade Course No		period	use in a course	purpose, motivation	task	experience	did PeerWise activities*	qestions created answers			
1	Semestral Project 2 (2014) Ob, Ex+In	1	I 2014 <b>Pilot</b>	1 <sup>st</sup>	T1	Q <b>presentation</b> / A motivation	1Q /3A	1 <sup>st</sup>	46 (= 98 %) 46Q 567A	1Q 12.3A	
2	Database Systems 2(2014) El, Ex+In	3				1 <sup>st</sup>	Q <b>motivation</b> for final exam (understanding) / A learning	3Q /A	1 <sup>st</sup>	8 (= 80 %) 18Q 164A	2.25Q 20.5A
+ students from course No 6 (2015), In		I 2015				2 <sup>nd</sup>	exercise Q / A learning	Q/A	1 <sup>st</sup>	13TQ 18 6Q 130A	0.3Q 7.2A
3	Semestral Project 1 Ob, Ex+In	1	II 2014	1 <sup>st</sup>	T2	Q <b>presentation</b> / A motivation	3Q/A	1 <sup>st</sup>	44 118Q 598A	2.7Q 13.6A	
4	Database Systems1 Ob, Ex+In	2		1 <sup>st</sup>		Q <b>motivation</b> for understanding / A learning	2Q/A	2 <sup>nd</sup> (after c. No 1)	36 70Q 356A	1.9Q 9.9A	
5	Semestral Project 2 (2015) Ob, Ex+In	1	I 2015	2 <sup>nd</sup>	T3	Q <b>presentation</b> / A motivation	3Q/A	2 <sup>nd</sup> (after c. No 3)	39 Q117 A846	3Q 1.7A	
6	Database Systems 2 (2015) El, Ex+In	3		2 <sup>nd</sup> (after c. No2)		Q / A Learning	3Q/A	1 <sup>st</sup> + c. No 2 (2015)	16 48Q 552A 9C	3Q 4.5A 0.5C	
7	Multimedia El, In	3	II 2015 <b>pilot</b>	1 <sup>st</sup>	T2	Q <b>motivation</b> for final exam (understanding) /A learning	1per topic (11) Q /A	3 <sup>rd</sup> (after c. No 5)	22 (= 88 %) 188Q 1216A 3C	8.5Q 55.3A	
8	Introduction to Informatics, Ob, In	1	II 2015 <b>pilot</b>	1 <sup>st</sup>	T3	Q motivation / A	Q/A	1 <sup>st</sup>	44 +TQ 12Q, 50A, 7C		
TOTAL							273 students				
<b>Explanations:</b> c. No ... course number Ob / El ... obligatory / elective subjects Ex / In ... external / internal study period I / II ... summer term / winter term											
T ... teacher *PeerWise activities Q / A / C ... questions / answers / comments TQ...teacher questions											

Similar to Paterson, Wilson and Leimich (2010), we used the PeerWise system in an obligatory introductory database class (Database Systems 1) and in continuing elective database courses (Database Systems 2). Our aim was to offer students the experience with an interesting information system because the core of each information system is a database. The second purpose was to engage students more in order to increase understanding of the course material presented.

Students in our courses were required to use PeerWise in a way, which can be seen in Table 1, column Teachers / purpose, motivation. It shows a minimum count of questions and answers required by the teacher (Table 1, column Teachers / task). Students had to create questions together with explanations to correct answers (see Figure 1, answer

distractor marked\* and part Explanation). Similar to Denny, et al. (2008b) there was no requirement to provide any written feedback on the questions answered but some students did so. Students had to categorize their questions with a correct tag (see Figure 1, part Tags). We agree with Paterson, Wilson and Leimich (2010) that topic coverage „gives a collective view of the students’ viewpoint on the course material and the relative importance of each topic”. We used the ACM computing classification system (ACM, 2015) as topic descriptors in semestral project courses. In addition, we used the titles of course material chapters as topic descriptors in database systems courses.


<p>Course No 1 (see Table 1) (Semestral project 2, summer term 2014)</p> <p>ID: 997686 Created: 5:35pm, 21 Apr 2014</p> <p><b>Question:</b> Aký typ materiálu sa používa v 3D tlačiarne s technológiou FDM (Fused Deposition Modeling)?</p> <p>*a) plast b) kov c) sadrovcový prášok d) tekutá živica e) cukor</p>  <p><b>Explanation:</b> Ako stavebný materiál je použitý plast ABS (používaný ako základný materiál známej stavebnice LEGO) alebo PLA plast vyrobený na prírodnej báze.</p> <p><b>Tags:</b> B-4-2, 3D tlačiarne</p> <p><b>Author:</b> UsernameTP (Identifier12430)</p> <p><b>Avg Rating:</b> 3.5000</p> <p><b>Avg Difficulty:</b> 0.5000</p> <p><b>Total ratings:</b> 6</p>	<p>Course No 7 (see Table 1) (Multimedia, winter term 2015)</p> <p>ID: 1861673 Created: 10:49pm, 13 Dec 2015</p> <p><b>Question:</b> Je možné nami (ľudstvu) dostupnými prostriedkami dosiahnuť kvalitu digitalizovaného zvuku, ktorá je bezstratová voči zvuku analógovému?</p> <p>a) Áno *b) Nie</p> <p><b>Explanation:</b> Vzorkovanie je vždy stratová činnosť - tam kde sa odoberá vzorka, tam sa vždy zvyšok stráca.</p> <p><b>Tags:</b> Zvuk</p> <p><b>Author:</b> UsernameMK (Identifier MK)</p> <p><b>Avg Rating:</b> 2.5000</p> <p><b>Avg Difficulty:</b> 1.2500</p> <p><b>Total ratings:</b> 4</p>
<p>Translated into English:</p> <p><b>Question:</b> What type of material is used in a 3D printer with FDM technology (Fused Deposition Modeling)? *a) plastic b) metal c) gypsum powder d) liquid resin e) sugar</p> <p><b>Explanation:</b> ABS plastic is used as a building material (also used as a basic material for the famous LEGO plastic bricks) or PLA plastic made on a natural basis.</p> <p><b>Tags:</b> B-4-2, 3D printers</p>	
<p><b>Question:</b> Is it possible to achieve analogue audio quality of lossless sound digitalization by using technology available nowadays? Yes *b) No</p> <p><b>Explanation:</b> By sampling we always lose a part of information between consecutive samples.</p> <p><b>Tags:</b> Sound (audio)</p>	

Figure 1: Examples of students’ questions, in Slovak (PeerWise Matej Bel University, 2016).

The system has been used in 3 semestral project courses and 3 database systems courses. The main purpose (see Table1, column Teachers / purpose) of using the system in database courses was to better understand source material of the course. The main purpose in semestral project courses was to present new topics and motivate students to learn and better understand them. In order to encourage participation in PeerWise, we awarded participating students from 5 to 10 % of the overall module mark. In some courses (see the column Teacher / task) students were required to contribute with the exact number of questions and answers. They had to provide an explanation to the correct answer designed by them, too. Before giving the final mark for a course to a student, we checked his questions and answers in PeerWise. Only if students contributed to the course material this way (the exact number of good questions designed and the exact number of correct answers for other students’ questions), they could reach the full mark for passing the course. Similarly to Paterson, Wilson and Leimich (2010), we have received no complaints about the system’s use or the resulting grade – this indicates that students do find the system fair. We agree with Paterson, Wilson and Leimich (2010) that the use of PeerWise within computer science courses may have one additional use which is unique within our discipline: students use a real database of questions. Hence, this is a good example of case study which demonstrates the real-world importance of databases. They

can find out various possibilities of this tool and test it as regular users. This can bring them deeper understanding of the various requirements for designing such a learning environment. There is also the possibility for users to provide feedback directly to the PeerWise creator.

### **The use of PeerWise in the Introduction to Informatics subject**

Introduction to Informatics is an introductory course in both Applied Informatics and Teacher Training in Informatics study programmes in their 1<sup>st</sup> semester. The aim of this subject is to have the same starting line for students who come from different types of secondary schools and with different knowledge of the informatics field. We experience the need for such a subject despite the fact that schools in Slovakia should follow the State Educational Programme which is implemented in their school educational programmes. These programmes contain topics which should be taught in Informatics. In the academic year 2015/16, we started our new accreditation period which gave us the possibility to enhance the way in which this “starting-line” knowledge is introduced. We are using different methods which can give us an overview on how students are prepared from the different areas which can be found in the informatics courses. This also provides feedback for students in terms of what they should improve in their study. This year we introduced the PeerWise system to our full-time students as part of this subject on a voluntary basis (Table 1, course No8). Students had the possibility to see the new system, to answer sample questions entered by the teacher of the course, and to try to create their own questions. Based on our previous didactical and methodological experience in this area, which included different activities in teacher-oriented systems and projects concerning question creation for didactical tests, we wanted to know how this system can be combined with student learning and positive approach to learning.

From the researcher's point of view, we used the methods of qualitative research and tried to answer these research questions: Are students of informatics able to adapt to a new system which they have never seen before? What can be the motivation for the students of an introductory course to use the PeerWise system? Do students tend to create questions or just answer questions which are already created? 44 students took part in this pilot experiment but not many of them played that active role in creating questions as we had thought in the beginning (see Table 1). The main activity was done in seminars where we discussed the course topics (Binary arithmetics and encoding, Logical operations and functions, Computer history, Basics of operating systems, Basics of internet technologies, Programming paradigms, Application of ICT). As it is usual at this kind of seminar, we processed the questions and tasks with students divided into two groups each having 2-hour seminar weekly. There was no difference in these groups as we discussed the same topics and same questions. We could see the answers from active students on questions inserted by the teacher of the course and also some of the questions inserted by students which were mostly similar to the teacher's ones. These worked as a starting point for similar questions and tasks which were done at the seminar. Based on this activity, students were able to revise what they had already known and what they should have improved in. In the next year, we would like to repeat this activity and enhance the use of this tool in this introductory subject.

Our suggestions and improvements for the next year will be: to prepare more questions from topics which were not very well answered in the final test (binary coding,

binary arithmetics, logical operations). We will also put more emphasis on discussion about distractors in questions. We will try to improve the motivational part and the desire to contribute with own questions, although we believe that students at this level will still tend to just answer the questions rather than create new ones. We will use this tool also with external students of applied informatics.

### The use of PeerWise in the Multimedia subject

For nearly 20 years now, the Multimedia subject has been taught at the Department of Computer Science. The content of this subject is annually updated, with teaching methods and forms being modernized and the whole subject in general is adapted to new trends in education. To support the Multimedia subject, a course of the same name was established in LMS Moodle. Apart from numerous study material and self-tests which can be found online, students can also find there a variety of different assignments and their solutions (Horváthová and Trajtel', 2015). During the winter semester 2015, a pilot experiment with the PeerWise system was held within the Multimedia course (Table 1, course No7). We were inspired by research of Denny (2015) so the main goal was to find out the influence of the PeerWise system usage in the preparation for the final testing.

The course called MUME 2015 was created in the PeerWise system (Figure 2). 23 full-time students of applied informatics and 2 students of teacher training in informatics had the opportunity to participate in the questions preparation voluntarily. 188 questions were created from which the best ones were chosen also for the final test. This meant that the students had motivation to create interesting questions and appropriately difficult answers. As we can see from the figure 2, out of 25 students, 22 were active (3 students did not participate, which is explained later), and the system counts also with the teacher as an active identifier, therefore 23 out of 26 were active.



MUME 2015					
Course ID	Identifiers active	Questions	Answers	Comments	Last correct answer
12401	23 / 26	188	1216	3	10:59pm, 07 Jan

Figure 2: MUME 2015 course in PeerWise system (PeerWise Matej Bel University, 2016)

To enter the system after the registration, each student was given Course ID and his personal identifier for this course. After students inserted their own questions (there are 11 topics in the subject Multimedia, so most of them created 11 questions) into the system, they were able to answer the questions of their classmates. In addition to that, they also had the possibility to evaluate the difficulty of each question and write a comment if they wanted to. There were 3 comments from one of our best students, who commented on the ambiguous answers of his classmates. All the information about the students, their activities and success rates, about created questions and other interesting statistics were available to the teacher also after the completion of the experiment. Because students usually do not want to do something what they must, this activity was made voluntary and the only motivation were points awarded for each valuable question with interesting answers. Although there was not a great interest for the PeerWise system at the beginning, later 88% of students took part in this experiment. 3 students of applied informatics did not even register to the system.

At the end of the semester, an overall assessment of the subject took place, consisting of homework evaluation and completion of the final test (Horváthová, 2015). The final

testing was performed in the universal testing system (Horváthová, Jacková and Brodenec, 2014). Some of the best PeerWise questions were added into the final test, which might have helped some of the students to achieve better results. The table 2 shows results from the PeerWise system as well as results of the overall evaluation or the final testing of the Multimedia subject.

After the completion of the course, the students could fill out an online questionnaire within Moodle and give their opinion, whether the PeerWise helped them to prepare for the final test or not. The table 2 summarizes also this feedback from students in this questionnaire. In most cases, student's result from the course (evaluation of the final test) corresponds with the number of questions, eventually with the number of answers. 36% of students who achieved an overall rating A or B, considered positive impact of PeerWise on their excellent result in the subject. Another 36% of students who achieved rating C, D or E admitted that the PeerWise might have helped them. Another 16% of students who did not stay in the system for long and created or answered only a few questions, noted self-critically, that the system did not help them at all. Only one student had failed the Multimedia subject. The remaining 12% of students, as was already mentioned before, did neither register nor login into the system. All these students had problems to pass the subject for the first time and they succeeded only on their second attempt with mark E.

Table 2: The table of results in PeerWise system and evaluation in Multimedia subject

Participation summary in PeerWise					SUBJECT MULTIMEDIA	QUESTIONNAIRE
ID	Questions	Answers	Q+A	Evaluation of the final test	PeerWise helped me? (1-Yes, 2-maybe, 3-no)	
1	B12	0	194	194	A	1
2	B09	11	183	194	D	2
3	B06	11	149	160	A	1
4	B08	11	136	147	A	1
5	B01	11	132	143	B	1
6	B04	11	132	143	B	1
7	B11	0	106	106	C	2
8	A03	11	57	68	C	2
9	A06	5	50	55	B	2
10	A08	9	30	39	E	2
11	B03	11	19	30	B	1
12	A11	11	11	22	A	1
13	A02	11	9	20	D	1
14	A05	13	1	14	C	2
15	B13	11	1	12	C	2
16	A09	11	1	12	C	2
17	MK	11	0	11	B	1
18	B02	11	0	11	E	3
19	DS	11	0	11	Fx	3
20	B05	7	0	7	A	1
21	B07	0	3	3	E	3
22	A12	0	0	0	D	3
23	B10	---	---		E	3
24	A13	---	---		E	3
25	A07	---	---		E	3

It follows that even though we have not yet had the opportunity to compare the results of this experiment with the previous years in the Multimedia subject (the PeerWise system was used for the first time and also the development and innovations of the subject cause modifications in the testing system every year), from this one-time usage of Peerwise we were able to deduce its positive impact on the preparation for the final

evaluation. When using the system, we discovered its hidden drawbacks which we would like to highlight. Before entering the questions, it is not possible to create topics (categories), in which the individual question could be placed. Of course the teacher can do this, but only when he/she enters the first few questions and with these questions he/she creates each topic separately. Another limitation that is resolved in our universal test system for final testing, is the possibility to enter only one correct answer. Such system of one correct answer is simpler for the student and thus easier for him/her to guess. In any case, we are very pleased that we were able to test the PeerWise system and we wish its creators a lot of satisfied users.

## DISCUSSION AND CONCLUSION

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So far we have obtained experience and preliminary results with the PeerWise system from 8 various computer science courses (4 different types) taught by 3 teachers at our university (see Table 1) at the Department of Computer Science. 2 teachers included the use of this system to their courses for the first time in 2015. We have summarized main facts about these courses in Table 1 and have discussed the main results in individual courses in 3 subsections of the previous chapter from the point of view of the 3 teachers who taught these courses. Compared to Paterson, Wilson and Leimich (2010) we also used teachers' questions in our Peerwise banks of questions. This had a number of purposes: to motivate students to start contributing with their own contributions, to show the design of well designed questions, to cover the basic material of the course, etc. Preliminary work has been done in analysing students' behaviour when this system for collaborated creation of MCQs is used as a part of students' course activities. We focused on mapping various possibilities of using the PeerWise system in our courses. We found out that the system was accepted by students very well in 7 courses (courses No1-No6, No8) as a support and supplement of the course material. In our opinion, similar to Denny, et al. (2011), motivation of teachers to use the system within their courses is a key element to the successful use of PeerWise by students. It corresponds with our results and observations of students' behavior. Students have to understand the meaning of activities required to do in the system. In other words, our students want to use this system but they need to see the benefit of it for their learning and for passing the courses. So this is primarily a task for their teachers to better understand the possibilities of the system and to be motivated enough to effectively use it in their courses.

To support students' engaged learning, we used the PeerWise system in 2 various semestral project courses (twice in one of them), 2 various database courses (twice in one of them), in an introductory informatics course and in a multimedia course. In this paper we summarized this experience, our results and gave implications to the future use. For future research, we would like to investigate the quality of students' questions and their preferences of topics in our courses, and to evaluate the contribution of Contributing Student Pedagogy approach to the students' learning experience.

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# Parallel Computing of Visibility Analysis Directed by Students

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## **Abstract**

*Capacity of GIS to analyse large areas with huge volumes of spatial data has led to an extraordinary proliferation of applications. Students of study program in Environmental Science (ES) are learning GIS analysis to be able to manage conflicts of interest in the country and assess the impacts of human activity on the environment components. Analysis of visibility are the spatial analysis, widely used in professional experience of graduates in ES, are. The analysis of visibility is a part of the curriculum within the course "Advanced GIS Analysis" in ES master degree. Computation of visibility for a specific area in large scale requires a number of time-consuming computations. There are several possibilities for speeding up the computation. Our approach to speed up the process is based on use of parallel computations. The analysis of visibility is, therefore a systematic approach from teacher is required. Students must handle the series of logically interrelating operations in order to proceed the analysis of visibility. These facts, as well as the very practical nature of the visibility analysis, make it a very good topic for project-based learning. We have created a model of project-based learning designed for students of 1<sup>st</sup> year of master study program in ES. Student projects are focused on assessment of visual impact of wind turbines on the landscape. The topic requires a complex approach, therefore it needs knowledge and skills in data capturing, sharing and analysing, parallel computing, individual and team work.*

## **Keywords**

*Project-based learning. GIS analysis. Parallel processing.*

## **INTRODUCTION**

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Environmental Science (ES) is an interdisciplinary academic field, what largely affects study and practical training of students in Environmental Science study program on Faculty of Natural Sciences at Constantine the Philosopher University in Nitra. In practice, graduates of the study program are expected to manage conflicts of interest in the country and assess the impacts of human activity on the individual environment components. Both mentioned problems require data analysis and synthesis from various scientific fields. We have to adapt the content and process of teaching conditions in favour of solving this tasks by graduates professionally. They need to know all relevant input factors and phenomena, acquire and process them efficiently, overlap them logically, subject them to spatial

analysis and synthesis and acquired results precisely evaluate and interpret. It is also necessary to use such ways and means which will enable the activities. A comprehensive solution provides the use of GIS, which can be defined as a system for capturing, storing, checking, manipulating, analysing and displaying data which are spatially referenced to the Earth (DoE, 1987). The true power of GIS lies in analysis. GIS analysis shows you patterns, relationships, and trends in your geographic data that help you understand how the world works, make the best choice from among options, or plan for the future (Mitchel, 1999).

Analysis of visibility are the spatial analysis, which are widely used in professional experience of graduates in ES. The analysis of visibility has been used in a wide range of applications, including the location of wind turbines (Miller et al., 1999; Bishop, 2002) and Observation Tower (Bao et al., 2010), assessment of landmarks visibility (Ogbum, 2005; Ohsawa, Kobayashi, 2005), analysis of archaeological locations (Paliou et al., 2011), evaluation of urban design (Yang et al., 2007; Dean, Lizarraga-Blackard, 2007), and assessment of land qualities (Sevenant, Antrop, 2007).

At present, the most common GIS software offers visibility analysis (viewshed) which are able to derive a new coverage from the digital elevation model (DEM) of the area. The newly created coverage shows those areas which are visible from one or more locations (Fisher, 1995).

The basic algorithm for analyse of viewshed from the DEM is based on the estimation of the elevation difference of intermediate pixels between the viewpoint and the target pixels. The determination whether the target pixels can be seen from the viewpoint is accomplished by examining each of the intermediate pixels between two cells to determine the corresponding 'line-of-sight' (LOS). If the land surface rises above the LOS, the target is invisible. Otherwise, it is visible from the viewpoint. The LOS computation is repeated for all target pixels from a set of viewpoints, and the set of targets which are visible from the viewpoints form a viewshed (Burrough, McDonnel, 1998; Kima et al., 2004).

Calculation of viewshed for a specific area in large scale requires a number of time-consuming computations.

The main factors that affect the total time of computation, besides the performance of the computer itself, are the numbers of viewpoints and target points in the visibility computation. The number of points is influenced by the resolution of the input DEM, size of the investigated area, and maximal distance from the viewpoint inside of which the visibility analysis will be performed.

There are several possibilities for speeding up the computation. One approach is described by Rana (2003) and Kima et al. (2004) as the reduction of the number of observers (viewpoints), targets, or both. One way to do so is to perform the analysis on a TIN rather than on a gridded DEM because there are far fewer points in a TIN than in a gridded DEM. An alternative approach is to use only a subset of the pixels as observers for each target.

## METHODS

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Our approach to speed up the process of viewshed calculation is based on using parallel computations according to Ferreira, et al. (2013).

Parallel computing is based on subdividing the observer's region of interest in N sectors around the observer (Fig.1). In the centre of the region different sectors are overlapping by width of one pixel in the place where the observer is located, thus, observer is situated by the means of he is concurrently included in all of created sectors. The parallelism of the calculation is designed in the way that the computation of visibility is carried out independently of each sector at the same computing time.

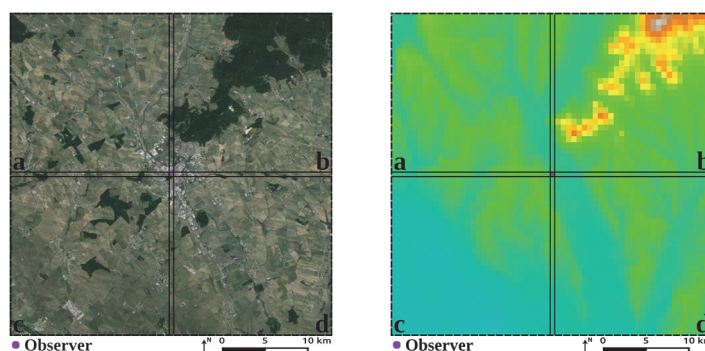


Figure 1: Subdividing the observer's region of interest in 2 and 4 sectors around the observer.

The analysis of visibility is part of ES master degree curriculum in within the course "Advanced GIS Analysis". Education is carried out using GRASS GIS 7.0 under Linux. GRASS GIS, commonly referred to as GRASS (Geographic Resources Analysis Support System) is a free and open source Geographic Information System software suite used for geospatial data management and analysis, image processing, graphics and maps production, spatial modelling, and visualization. GRASS GIS is currently used in academic and commercial settings around the world, as well as by many governmental agencies and environmental consulting companies. It is a founding member of the Open Source Geospatial Foundation (GRASS Development Team, 1998).

GRASS GIS supports parallel computing solution, which enables sophisticated spatial analysis calculations on larger data areas with large scales. The analysis of visibility is such kind of analysis, which is very suitable for parallel computation.

Solving of visibility analyses in education is a complex problem, and therefore a systematic approach from teacher is expected. Students must handle series of logically interrelated operations in order to proceed the analysis of visibility solution.

These facts as well as the very practical nature of the visibility analysis makes it in terms of project-based learning a good topic according to Diehl, Grobe, Lopez & Cabral (1999), Thomas (1998) and Mergendoller & Thomas (2000).

Aforementioned authors described the Project Based Learning (PBL) as a teaching and learning model that uses projects to engage students and focus their learning. Projects are complex tasks that involve students in design, problem-solving, decision-making, and investigative activities. Students work autonomously over extended periods of time, and

prepare realistic products or presentations (Diehl, Grobe, Lopez & Cabral, 1999; Thomas, 1998; Mergendoller & Thomas 2000).

Based on the principles of project teaching and recommendations for their creation by Thomas (2000) and Blumenfeld et al. (1991), we have created a model of project-based learning designed for students of 1st year of master degree study program in ES.

The proposal corresponds to the learning content as well as the implementation of the teaching of optional subject advanced analysis in GIS. The proposed project-based learning topic takes one semester; therefore the project requires the knowledge and skills acquired during each lesson of the course.

## **RESULTS**

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The proposal of project-based learning we created is dealing with a visibility of wind farms within the area of interest (e.g. administrative boundaries of the village).

Visual impact of wind turbines on the landscape can be a significant barrier to their consent and deployment. The issue is well documented in many scientific articles (e.g. Molina-Ruiz et al., 2011; Ladenburg, 2009; Bishop, 2007; Hurtado et al., 2004).

Successful encompassment of the “The visibility of wind turbines” project requires to get an essential knowledge and skills by students, which are taken not only from a specific analysis of visibility, but also from the methodology of obtaining the necessary geospatial data, methods for their subsequent processing, the underlying analysis and reports creating.

Figure 2 shows in detail the comprehensive overview at the logical sequence of the student projects formation.

The work on the project begins by importing the necessary data to the database GRASS. In our case it involves data with different capture process by Jackson & Woodsford (1991). The raster map layer, which represents digital elevation model, was created via primary data collection as a result of remote sensing. Vector map layer, created by secondary data capture techniques of manual digitizing the existing maps, represents a secondary data collection. Awareness of the way in which the layers were created directly affects the methods of further processing, because it affects their accuracy, detail and credibility.

In this step, inconsistency of coordinate systems must be dealt as a serious problem, which can prevent the execution of spatial analysis. Global coordinate system WGS 84 is defined for DEM and local coordinate system S-JTSK for vector layer representing administrative boundaries (in our case the boundaries of municipalities or districts). Local coordinate systems should be accepted and promoted either to calculate the position more precisely or to synchronize happenings (Munoz et al. 2009). Therefore, due to the unification of coordinate systems we will transform DEM layer into the S-JTSK coordinate system. Conversion of coordinates is similarly needed to locate the wind power plant accurately, which is digitally captured in WGS 84 coordinate system.

The second step is to set the region on the basis of computational border of the area. In our case these are administrative boundaries (of municipalities or districts). Along with

specific allocation of region boundaries, it is necessary to define the resolution in which all following operations will be performed. Resolution selection depends on the size of the area of interest, the desired degree of detail (generalization), but also on workstation performance, as upscaling increases demands on computer performance. After setting up the computational region it is possible to carry out data adaptations. From layer representing administrative units (municipalities and districts) it is necessary to choose area of interest and exercise its conversion to raster format.

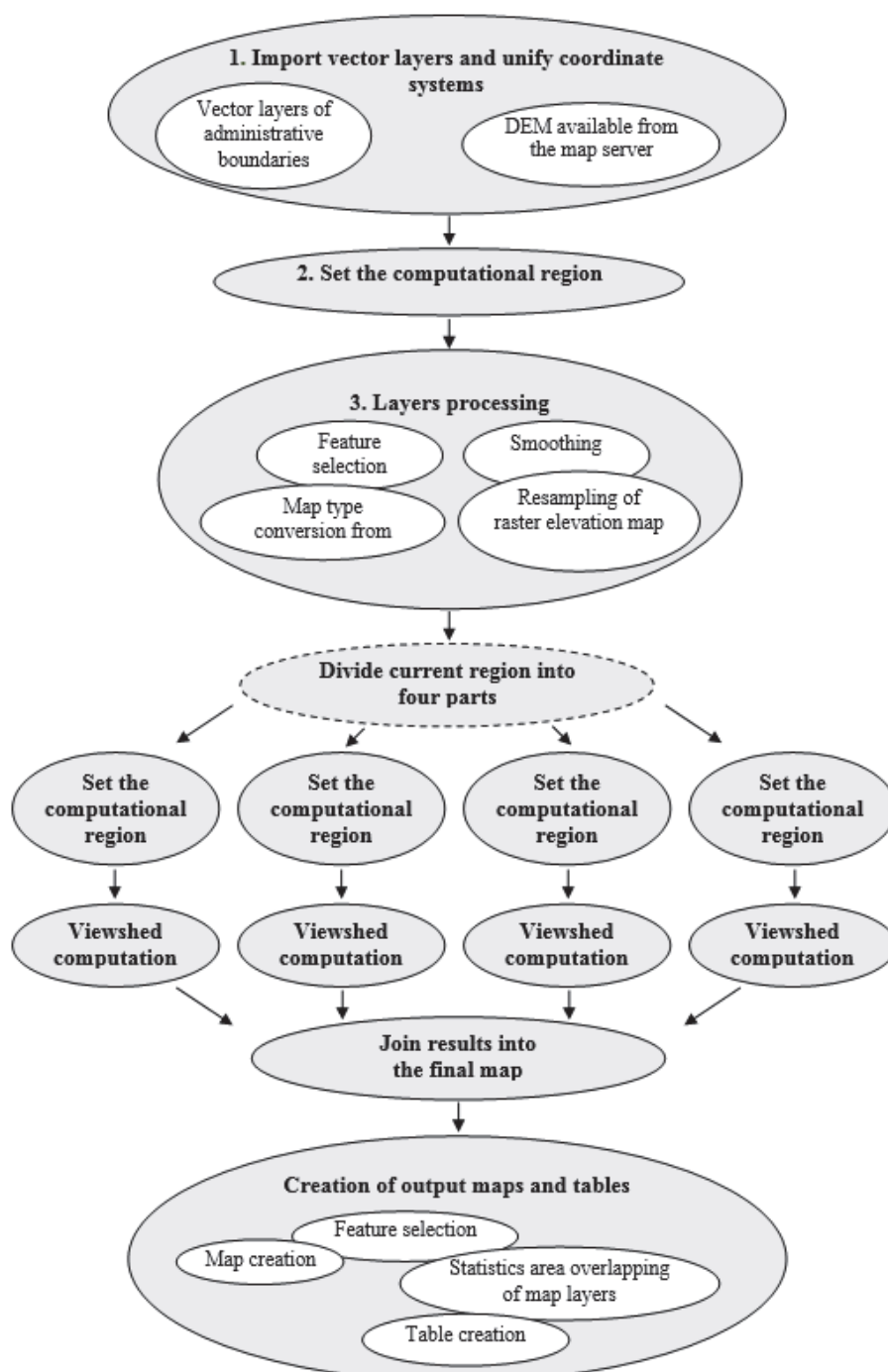


Figure 2: The logical sequence of steps that students apply in dealing with the projects



It is necessary to smooth out DEM raster layer that the calculations could not be affected by layer inaccuracies before the first use. If necessary, it is possible to use resampling and thereby change raster layer resolution. Resampling largely affects computation time, so the correct resolution setting is a very important element of the project. Next step is division of a given territory. The parallel computing allows us not only faster calculation, but also opens the possibility to produce outputs at a much more detailed resolution. Zoning for individual sectors is performed by computational region splitting. Its boundary coordinates are well known and as dividing factor acts the point representing the location of wind power plant. After area splitting the point will be located at the place where sectors are overlapping. It will be included in all sectors, because they overlap just by the width of this point (Fig. 3). The result of the division is a set of coordinates representing the new boundaries of individual sectors to be used for setting up new computational regions. Visibility calculation starts for each region separately.

GRASS GIS version 7.0 provides two tools to calculate the visibility `r.los` and `r.viewshed`:

- `r.los` – uses RFVS algorithm. According to Ferreira, et al. (2013) RFVS algorithm computes the terrain cells' visibility along rays (line segments) connecting the observer (in the centre of a cell) to the centre of all cells in the boundary of a square of side  $2\sqrt{2}+1$  centred at the observer (see Figure 3(a)). In each column, it tests the line of sight against the closest cell. Although a square was chosen for implementation simplicity, other shapes such as a circle would also work.
- `r.viewshed` - Van Kreveld's algorithm (Van Kreveld 1996) is fast viewshed algorithm. Its basic idea is to rotate a sweep line around the observer and compute the visibility of each cell when the sweep line passes over its centre. For that, it maintains a balanced binary tree that stores the slope of all cells currently being intersected by the sweep line, keyed by their distance from the observer. When this sweep line passes over the centre of a cell *c*, the agenda is searched to check *c*'s visibility (Ferreira, et al. 2013).

The following input parameters of both modules are important to compute a visibility for the whole area of interest:

- the raster map layer containing the elevation data used as a program input,
- the Geographic coordinates identifying the desired location of the viewpoint (wind turbines),
- the value Height of the observer above the viewpoint's elevation (the average height of the turbine is 100 meters).

Results of computation are indeed multiple map layers; however in real they present one comprehensive output. Therefore it is necessary to combine various map layers into one final map. The final map shows the areas, where the wind turbines will be visible from (Figure 3).

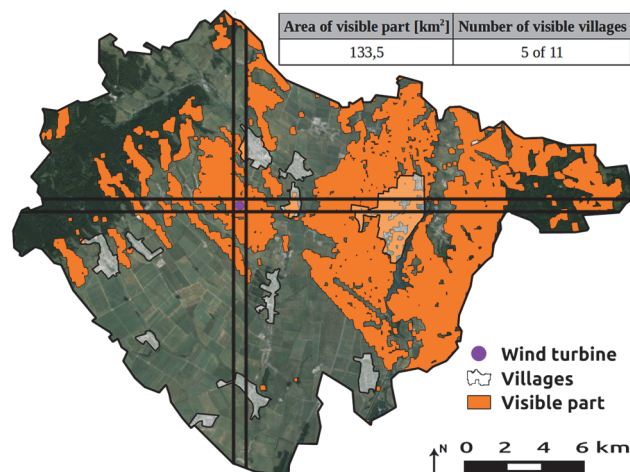


Figure 3: Visibility of wind turbines within the area of interest

It will be also possible to assess the visual impact of wind turbines for the residents of the village. In this step, the work of individuals is finished, but the team does not stop work on the project itself. During the semester every student works with different data on the same common task. Combination of students' works provides new values and results. Issue can be solved in two different ways: The first method according to Grežo & Jakab (2014) is typical for cases where students are working on adjacent areas of interest. Every newly annexed area increases size of the final map. This method is suitable only for the cases, where the results are particular and independent on each other. Such as the possible morphometric analysis computations (aspect, slope), where results recorded in cells of the grid affects cells in neighbourhood.

In the above mentioned case, computation of the visibility of wind turbines would not be efficient, since the visibility of wind turbines may exceed the borders of the area of interest and it has an impact on the territories in surrounding. There is a second option how to solve visibility analyses for several wind farms within one area of interest. Figure 4 (a-c) shows partial solution outputs provided by students separately, while Figure 5 the final composition of the same territory.

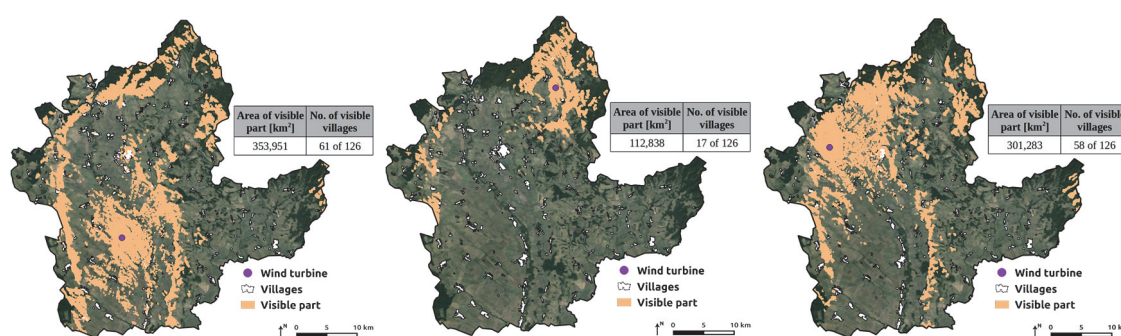


Figure 4: Preview of the visibility results of several wind turbines in one area of interest

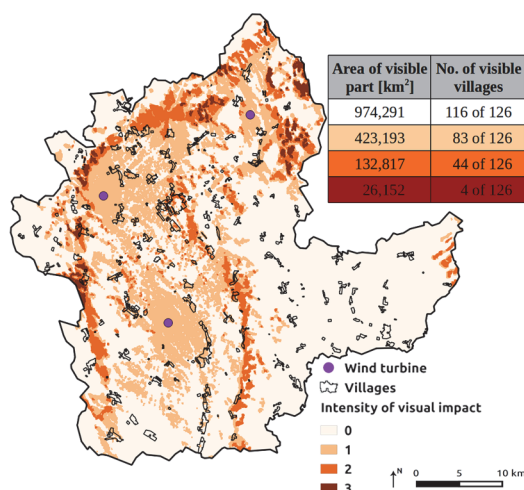


Figure 5: The final map of visibility of three wind turbines

The final map aggregates various map layers using the map algebra (Figure 5). On the one hand it is possible to distinguish places from which you can see wind turbine, on the other hand each point express in numbers how many wind turbines are visible. This exactly determines the visual impact of wind turbines in the area. While previous work of students was based on an individual approach, at this stage of project-based learning, the work in group is necessary. Before the patching, it is necessary that students have agreed on resolution of the resulting map and then they can harmonize next steps. Exact specifications of final map can be consulted using discussion tools in e-learning and method of map publishing depends on chosen GIS server.

## DISCUSSION

Coming from the content and process aspects of the model design, as well as previous experience with implementation of project-based learning (PBL), we can suggest some ideas and recommendations for teaching practice. The project teaching model proposed is based on the principles as follows:

1. **PBL project is central, not peripheral to the curriculum** According to this defined feature, projects are the curriculum (Thomas, 2000). Within our model of PBL, the project is the central teaching strategy; students learn the central concepts of the discipline via the project.
2. **The practical nature of the project topics** – According to (Blumenfeld et al., 1991.) project-based learning places students in realistic, contextualized problem-solving environments. In so doing, projects can serve to build bridges between phenomena in the classroom and real-life experiences; the questions and answers that arise in their daily enterprise are given value and are shown to be open to systematic inquiry. Our model was created on a practical basis because the topic Visual Impact Assessment of wind turbine solves a real conflict of interest and students as real assessors need to determine the level of visual impact of wind turbine on the village. The assessment of specific human

activities on the environment reflects a possible real-world problem that students might encounter in the future.

3. **Problem solving with professional tools and real data** – Students have to prepare exact solutions for the problems posed by solving individual tasks, using real data and professional GIS software. These modern methods of processing and analysing of data are highly required in the practice, so the graduates acquire knowledge and skills that enhance their attractiveness on the labour market.
4. **Interdisciplinary approach and wide range of knowledge and acquired skills** – Proper use of GIS requires knowledge of geography, geoinformatics, cartography, mathematics, and database systems. To the problem belongs also application part consisting of the wind turbines issue and environmental impact evaluation.
5. **Projects are student-driven to some significant degree** – According to (Thomas, 2000) projects are student-driven to some significant degree. PBL projects are not, in the main, teacher-led, scripted, or packaged. Within our model, projects do not end up at a predetermined outcome or take predetermined paths. PBL projects incorporate a good deal more student autonomy, choice, unsupervised work time, and responsibility than traditional instruction and traditional projects.
6. Figure 2 contains a diagram describing the logical sequence of the project implementation steps, but at every step the student has the opportunity to decide which from a variety of GIS tools and settings intends use. Freedom of choice presents also setting of resolution, degree of input data generalization, methods of raster smoothing, dividing computational region into sectors, number of its sectors and number of concurrently realized computations (2,4), as well as tool to calculate visibility selection (`r.los`, `r.viewshed`).
7. **The teacher as classroom manager** – We agree with Blumenfeld et al. (1991.) according to who in PBL very little time is devoted to teacher-directed seatwork or whole-class discussions. Students spend the majority of their time working on their own or in small groups. Teachers typically do not lead instructional activities, nor do they dispense resources, or present material to be learned. Students find their own sources, conduct their own research, and secure their own feedback. Experienced PBL teachers report that they spend very little time promoting student engagement or handling student misbehaviour. Teachers often spend their time participating in projects as peers rather than as classroom managers.

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## ACKNOWLEDGMENTS

The work was supported by the projects VEGA 1/0109/13 and KEGA 025UKF-4/2015

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# Facebook use by University Students: From Intense use to addictive behaviour

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## Abstract

*The intense use of Facebook by university students is raising several questions regarding the influence of the social networking websites on the educational processes. While social learning theories advocate towards the diversification of teaching methods, the important amount of time spent by students on social networking websites may negatively influence the learning outcomes. Recent work shows that university students have large Facebook networks, log on several times per day and spend a lot of time on the website. The question is how much of this intense Facebook use is due to an addictive behavior. The objective of this paper is to present a multi-level multiple linear regression model that explains the influence an addictive behavior has on the number of minutes spent daily on Facebook. The model is using the following variables: the withdrawal syndrome scale, the network size, the frequency of use, and the time spent on Facebook. The model has been tested on a sample (N=204) collected in 2015 from a Romanian university. The results reveal that the addictive behavior has an indirect effect on the time spent on Facebook, which is mediated by the network size and the frequency of use.*

## Keywords

*Facebook. Social networking websites. Intense use. Addictive behavior. Withdrawal syndrome.*

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## INTRODUCTION

Facebook is a very popular network among university students (Lamanauskas et al., 2013). Recent work shows that students have large Facebook networks, log on several times per day (or are continuously logged on) and spend many minutes every day (Iordache et al., 2015; Manea et al., 2015). The use of social networking websites takes a lot of time from the students' university life.

The usage of social networking websites is continuously growing. On the one hand, this happens due to a rapid information communication technology development (in a quantitative and qualitative sense), on the other hand, due to the interests and demands of the consumers themselves. Social networks are "moving" into educational space as



well. At present, a lot of various social networks (or technologies devoted to social network creation and their effective usage) are used not only for entertainment, leisure time or communication but also for teaching/learning purposes. Therefore, it is important to understand the main motives of using social networking websites, to analyze their probable disadvantages and advantages. The institutions of adult and higher education inevitably have to face the technology-driven challenges.

Social networking websites provide new opportunities for the educational sector. The social media technologies provide bigger possibilities for learning in cooperation, encourage the learner's creativity, independence, motivation, participation in learning activities, and provide students with the possibility to take on responsibility for their learning process.

It is obvious, that students want to get information from multimedia sources quickly; they like to process information concurrently obtained from parallel sources and do several activities at the same time. Students like to learn using internet conversations, applications which they can control, for example, image games, modelling, cafes, internet diaries, wikis, sound and image records. Speaking about communication, one can assert that they are accustomed to communicating on the internet with many people at the same time and they work best while being in the net. Current research shows that students of various ages use social network cafes, however, the frequency of usage differs (Roblyer, McDaniel, Webb, Herman, Witty, 2010; Lamanauskas, Šlekienė, Ragulienė, 2013; Iordache, Lamanauskas, 2013).

The use of SNW for educational purposes raises considerable controversies and the research of the issues in question on the European level and globally is not sufficient (Vaičiūnienė, Mažeikienė, 2012). It is obvious, that the utilization of SNW (Facebook, in particular) for educational purposes should be fostered, and awareness about the possibilities offered by SNW in study process should be raised. On the other hand, certain possible addictions using SNW must be analyzed in parallel.

The question is how much of the intense Facebook use is due to an addictive behavior. In other words, how much is use and how much is abuse? The objective of this paper is to present a multi-level regression model that explains the influence of the addictive behavior on the main characteristics of use. The model is using the withdrawal syndrome scale and three characteristics of use: the network size (number of Facebook friends), the frequency of use (days per week and logs per days), and the time spent on Facebook.

This work is part of a larger study carried on in a cooperation framework between Romanian and Lithuanian researchers. An evaluation instrument has been developed and administrated in Lithuania and Romania (Iordache et al., 2015). For this study, a sample of 204 students from a Romanian university is used to test the model.

## RELATED WORK

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Social networking websites have been extensively studied from different theoretical perspectives by using both qualitative and quantitative approaches. Although there are many studies reporting an intense Facebook use, few approaches exist that explain how much is abuse.

Regardless of certain negative aspects of SNW usage, they remain potentially positive, enabling students of using various information sources, communication and other possibilities. The researchers state that Facebook could be seen as a vital contribution to the successful provision of offline university education (Selwyn, 2009). A recent study shows that university-related issues are an important reason for using Facebook by the Romanian students, although not the first one (Manea et al., 2015).

The research carried out in Turkey showed that after three months' educational intervention, exceptionally using Facebook for learning, the students' attitudes remained strikingly heterogeneous (Kayri, Çakır, 2010). It is interesting that this research showed, that the students, who spent much time on Facebook perceived Facebook as an educational tool. The research, carried out in Serbia showed, that using social networking tools, such as Facebook, increases the productivity of students and improves their interest in environmental issues (Petrović, Petrović, Jeremić, Milenković, Ćirović, 2012). The researchers make a conclusion, that such approach is useful and has great social value. Similar results are presented by USA researchers, showing that students believed that they learned more by using Facebook and would like to use Facebook for other educational purposes (Pollara, Zhu, 2011).

One cannot forget that university students are the recipients of teaching service, evaluators, who are open to new innovative technologies and willingly accept new study forms and methods. The teacher also has to accept the lifelong learning challenge and to orientate himself towards open studies and e-learning, which becomes an inseparable part of any study form. Students like SNW, because they can communicate with acquaintances, friends and relatives living abroad, to get acquainted with various people, find useful, suitable information, share it with the other portal members, and entertain themselves by playing games, listening to music, looking at the photos. To create a personal SNW profile, the students are encouraged by friends, relatives, a wish to find out how everything is going on, a wish to broaden one's outlook, not to fall behind, to pursue novelties. Profile creation is also determined by the possibility to quickly keep in touch, an easy and visual communication with portal participants, a wish to get acquainted and show oneself and various games.

Students usually point out such *SNW advantages* as possibility to communicate with many people at the same time, to keep in touch with the people they know from long time ago, with friends and relatives living abroad, the possibility to find suitable information and share it, self-realization possibility, because one can freely express ideas, improve English knowledge, virtual communication skills, possibility to find friends, new acquaintances.

Students notice SNW disadvantages as well. This is related to the information public announcements, lack of privacy, presented data, which are not safe, possible lies, frauds, lots of incorrect information, and danger to get acquainted with bad people. Participation in SNW takes a lot of time, which affects the concentration on studies. SNW abuse not only increases addiction, but also distracts from real communication, communication skills in real life decrease, and may cause alienation. Some information is not suitable for children and teenagers. It has been noticed that long sitting at the computer is harmful to health, has a negative effect on a general condition of a man (Lamanaukas, Šlekienė, Ragulienė, 2013).

It is obvious, that both the internet and SNW (Facebook in particular) usage have certain negative consequences as well. For example, students who spent more time on Facebook scored lower on an engagement scale. There was no relationship between time spent on Facebook and time spent studying (Junco, 2012). Social networks very often cause worry, the consumers feel constant pressure, that they constantly must be logged on. Various social networking websites, and especially "Facebook" are constantly advertised, all smart phones and many internet cafes encourage the students to use them. Besides, such networking websites regularly inform about consumer growth, inducing not to fall behind. So, addiction to social networks, as any other, starts to negatively affect everyday life, to hinder work, leisure time and even health.

Research studies, carried out in Lithuania, show that for young people, e.g., for teenagers, is characteristic behavior, dependent upon social networks. It has been established, that psychological, social dependent behavior features manifest themselves quite often and physiological ones – a little less (Bacys, 2013). The other research studies also show, that always increasing involvement and use of the Internet provided services often condition risky behavior as well (Paluckaitė, Žardeckaitė-Matulaitienė, 2015). Generalizing, one can assert, that the research carried out in Lithuania shows that a certain addiction to SNW occurs. People literacy decreases (slang appears), socialization problems arise (the communication goes in an indirect way, different kind of social skills are formed), the time expenses are quite often very big and ineffective (instead of doing something useful, such activity is taken up, which only "pushes" the time and so on.

The research carried out about the purposes of the Internet use among Turkish high school students according to their gender, frequency of Internet use, grade point average and family income, showed, that between these variables and problematic Internet use correlations are very important (Demirer, Bozoglan, 2015). The research carried out in Serbia showed that 46.4% of the respondents reported limited symptoms of addiction, while 47.6% of respondents reported pathological symptoms (Nicolović, Živković, Manasijević, Štrbac, 2014). It has been stated, that there are significant differences between a problematic internet usage and independent variables (gender, loneliness, and shyness) (Erolu, Pamuk, Pamuk, 2013), besides, the use of Facebook may contribute to the severity of symptoms associated with Internet addiction (Kittinger, Correia, Irons, 2012).

It is obvious, that positions are not only various but contradictory as well. The opinions about addiction to computer, internet, SNW are various. Some of them state, that it is only a habit, which can be controlled by a man himself, the others think, that it is a sick inclination, which takes possession of a man and without help it is not possible to put everything in order. It is important to emphasize, that on a scientific level, it is very little spoken about addiction to social networks, it is more spoken about addiction to the computer in general, where it is marked, that from it develops an addiction to the social networks. On the other hand, there is also little research in this domain exploring the relationships between academic success and level of Internet addiction.

## EMPIRICAL STUDY

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### Method and hypotheses

The method used in this study is based on a multi-level multiple regression model. In this model, the predictors of a dependent variable become dependent variable on the next level. The multi-level regression model has an increased explanatory power since it shows how some influences are mediated by endogenous variables (Cohen et al., 1993). The model was developed using SPSS for Windows then tested using Amos for Windows (Arbuckle, 2007). Model estimation allows checking the significance of relationships between variables. This study is using the following indices to assess the fit of the model with the data: Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR).

The dependent variable is the number of minutes spent on Facebook (USG). The independent variables are the Facebook addiction (AWS) measured with three items adapted from the withdrawal syndrome sub-scale (Masur et al., 2014), the network size (NET), measured with the number of Facebook friends, the frequency of used, measured with the number of days per week (W-FRQ) and the number of logs per day (D-FRQ). The empirical study is testing the following hypotheses:

- H1. Facebook addiction has a positive influence on the size of the Facebook network (AWS → NET).
- H2. Facebook addiction has a positive influence on the size of the weekly frequency of use (AWS → W-FRQ).
- H3. Facebook addiction has a positive influence on the size of the daily frequency of use (AWS → D-FRQ).
- H4. Facebook addiction has a positive influence on the number of minutes spent daily on Facebook (AWS → USG).
- H5. The size of the Facebook network has a positive influence on the weekly frequency of use (NET → W-FRQ).
- H6. The size of the Facebook network has a positive influence on the daily frequency of use (NET → D-FRQ).
- H7. The size of the Facebook network has a positive influence on the number of minutes spent daily on Facebook (NET → USG).
- H8. The weekly frequency of use has a positive influence on the daily frequency of use (W-FRQ → D-FRQ).
- H9. The weekly frequency of use has a positive influence on the number of minutes spent daily on Facebook (W-FRQ → USG).
- H10. The daily frequency of use has a positive influence on the number of minutes spent daily on Facebook (D-FRQ → USG).

### Sample

The sample includes 204 university students (114 men and 90 women) from a Romanian university. Participants were asked to answer some general questions and to

rate a set of statements on a 1 to 7 Likert scale. The age of participants is varying between 19 and 52 years with a mean of 25.89 (SD=7.68). The network size has a mean value of 641.13 (SD=801.94). Students are using Facebook six days per week (M=6.03, SD=1.63). The mean number of logs / day (measured on a 1 to 4 scale: once, twice, three times per day and more, continuous log) is 2.73 (SD=0.94) and the time spent in minutes / day is on average 71.24 (SD=80.86). As it could be observed, the university students have large Facebook networks and spend a lot of time on Facebook.

In order to eliminate the outliers, the number of Facebook friends has been scaled as follows: 1 (1-100), 2 (101-250), 3 (251-500), 4 (501-800), 5 (801-1200), 6 (1201-2000), and 7 (over 2000). In addition, the number of minutes spent daily has been scaled as follows: 1 (1-15), 2 (16-30), 3 (31-60), 4 (61-120), 5 (121-240), and 6 (over 240 minutes).

The descriptive statistics is presented in Table 1.

Table 1: Operationalization and descriptive statistics (N=204).

Item	Statement	Mean	SD
NET	How many friends do you have in your FB network? (scaled)	3.23	1.78
W-FRQ	How many days per week do you use Facebook?	6.03	1.63
D-FRQ	How many times per day do you log on Facebook?	2.73	0.94
USG	On average, how many minutes per day do you actually use Facebook? (scaled)	2.76	1.40
AWS1	If I am off Facebook for a longer period of time I feel nervous	2.42	1.92
AWS2	When I am not online I ask myself what happens on Facebook	2.86	1.96
AWS3	I feel out of touch when I haven't logged onto Facebook for a while	2.67	1.96

The mean value for the withdrawal syndrome scale is relatively low, much below the neutral value of 4.00.

## Model testing results

AWS has been separately analyzed for dimensionality, the internal consistency of the scale (Cronbach's alpha), and convergent validity (Hair et al., 2006). All items are over 0.8, which demonstrates the scale unidimensionality. The Cronbach's alpha is 0.909. The construct has convergent validity: the composite reliability is 0.90 and the average variance extracted is 0.769. Since the construct is unidimensional, the items could be averaged and the resulted means could be further used in the regression model as a single variable.

The model estimation results are presented in Figure 1, where only significant relationships are shown. The results indicated an excellent fit of the model with the data:  $\chi^2=2.077$ ,  $DF=2$ ,  $p=0.354$ ,  $\chi^2/DF=1.039$ ,  $TLI=0.998$ ,  $CFI=1.000$ ,  $SRMR = 0.021$ ,  $RMSEA=0.014$ . The model explains 4% of the variance in the network size, 34% variance in the daily frequency of use, and 21% of the variance in the time spent on Facebook. The daily frequency of use is the most important predictor of the time spent on Facebook.

The path from AWS to USG is not significant so H4 is not supported. This means that the Facebook addiction has not a direct effect on the time spent daily on Facebook. Also, the relationship between W-FRQ and USG is not significant, so H8 is not supported.

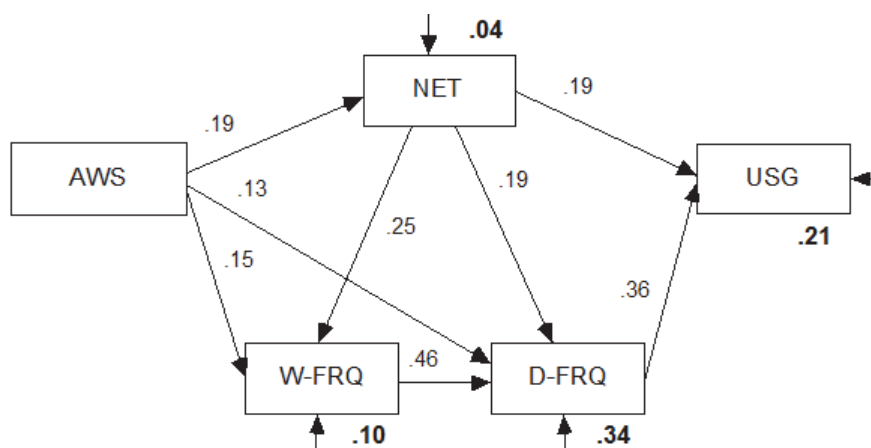


Figure 1: Model testing results.

As it could be observed in Figure 1, the addictive behavior (AWS) has an indirect positive influence on the time spent on Facebook. The influence is mediated by all the other variables. In this respect, three paths could be distinguished: AWS→NET→USG, AWS→W-FRQ→D-FRQ→USG, and AWS→D-FRQ→USG. Table 2 shows the results of the hypotheses testing (including the significance level) and the standardized direct, indirect, and total effects.

Table 2: Hypotheses testing results and standardized effects.

No.	Hypotheses	Sig.	Effects		
			Direct	Indirect	Total
H1	AWS → NET	0.006	0.189		0.189
H2	AWS → W-FRQ	0.023	0.153	0.048	0.201
H3	AWS → D-FRQ	0.023	0.133	0.128	0.260
H4	AWS → USG	n.s.		0.130	0.130
H5	NET → W-FRQ	0.000	0.253		0.253
H6	NET → D-FRQ	0.002	0.185	0.116	0.302
H7	NET → USG	0.005	0.188	0.109	0.297
H8	W-FRQ → D-FRQ	0.000	0.459	0	0.459
H9	W-FRQ → USG	n.s.		0.166	0.166
H10	D-FRQ → USG	0.000	0.363	0	0.363

Overall, the model testing confirmed most of the research hypotheses. The analysis of direct and indirect effects revealed that a too intense Facebook use leads to an increased frequency of use, which distract students from their university work. Although the network size is only slightly increased, there is a significant indirect influence on the time spent on Facebook.

## CONCLUSION

Social networking websites and especially Facebook raise many research questions regarding the impact on the educational process. However, it is still very little spoken about how and about the degree to which the addiction to Facebook is negatively affecting the academic performance. Also, despite the plethora of studies analyzing the

usage of social networking websites by university students, very little is known about how much of the time spent on Facebook is use and how much is abuse.

This study contributes with an empirically validated model explaining the influence of Facebook addiction on the main characteristics of use. The results show that the addiction is increasing the frequency of use and has a small influence on the size of the network. In turn, the network size and the frequency of use are influencing the amount of time spent on Facebook. Although the direct relationship between the Facebook addiction and the usage is not significant, the model reveals the indirect effects mediated by the network size and frequency of use. Overall, the model explains more than 20% of the variance in the time spent daily on Facebook by university students.

There are some inherent limitations of this work since the sample is relatively small. To achieve a deeper understanding of Facebook addiction among university students, larger samples are needed.

## ACKNOWLEDGEMENT

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This work was supported in part by a national grant financed by ANCS (Romania) under TEHSIN 0923 0207.

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# The Impact of Modern ICT-based Teaching and Learning Methods in Social Media and Networked Environment

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## **Abstract**

*One of the typical features of our information society is the fact that more and more social processes take place in digital networks and many elements of our life can be stored and analysed in digital format. Nonformal and informal education is gaining strength and more and more people can access knowledge, voices which have not been audible until now grow louder, open discussions have been initiated in topics of connectivism, networked learning, social media involvement into teaching process. The approaches in education focusing on the students' feedback have been acknowledged for a while thus in educational institutes students evaluate their teachers, the methods applied by their teachers and the effectiveness of these methods, they tell their opinions in connection with particular subjects. Nevertheless, surveys of this kind often provide distorted or incomplete answers. We should also examine the methods which are widespread and the impacts which are dominating social media. An approach of this kind is obvious for more than one reason. A bigger and bigger part of publicity moves to the Internet. The online environment provides the most democratic space to speak ever, especially the free writable surface of Web 2.0, social media and within that a social site providing an open surface for publishing and discussion that is Facebook. The online community uses this potential: more and more students express their opinion about particular subjects, learning methods and forms or evaluate teachers, institutions on social sites, blogs, forums. In this paper we describe a pilot research, a practice of the theories regarding the use of social media through a survey based on a big (N=122) sample. The results of this research can be used for elaborating the essential elements and frameworks of a methodological culture which involves new network-based features adaptable in micro-environments and for extending these frameworks over various learning environments.*

## **Keywords**

*Informal learning. Social networks. E-material. Electronic learning environment. Cloud technology.*

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## **INTRODUCTION**

The main feature of information society is that it brings focus to information becoming the most important value. Its rise was brought about by the globalization of

economy and the crisis of corporate management arising from that, the main movers of it were the rapid development of information technology and telecommunication, its main stages were the spread of personal computers and the of broadband data communication networks. (Paulsen, 2002; Forgó, 2011; Molnár, 2012; Buda, 2010). The Internet and mobile phones are its technological innovations with a symbolic significance (Szűts, 2014; Castells, 2005)

This involves important social changes: the proportion of the employees in informational sector is radically increasing, telework and lifelong learning becomes possible and necessary. As a result of these the improvement of the infrastructure of informatics and propagation of digital literacy may emerge as a highlighted strategic object. At the same time people living in information society have to face many hitherto unknown problems such as evaluating, filtering and processing information which is available in unlimited volume but of varying quality or defending the privacy against political and economic power which strive to obtain and control information. These effects change the environment for the members of the society and the nature of their work that is related to the attitudes, learning processes and habits of individuals or the changing roles of teachers and students.

## **THE IMPACT OF NEW TECHNOLOGIES ON ELECTRONIC LEARNING ENVIRONMENTS**

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As a result of the influence of the above described modern, day to day changing world higher education try to adapt to the new generation attitude, habits, learning style of students and started to switch over to electronic based educational systems labelled with the term 'e-learning'. Due to the effect of this educational institutions have launched and operated electronic learning environment.

Such learning environments can be created with Moodle, Olat, Ilias, Coedu, Claroline, CooSpace or Share point systems. Some of that can work in a synchronized connection with systems of administration and education – such as Neptun or ETR – used in higher education. Besides there is another tendency urging live lectures to be recorded and published in more and more institutions (Szűts, 2012a, b; Kommers, 2010).

With the help of these systems a long experience in higher education proved at a micro- and macro-level as well that while teaching activities in e-learning environments take place mainly in daytime periods, the activity of (full time) students take place mainly in late evening, night periods. The above mentioned online, internet-based learning support systems provide communication between continuous network nodes in a synchronous or asynchronous form which means communication between students and teachers.

The system of teachers-training programmes (postgraduate and postgraduate specialist training courses) of the Department of Technical Education at Budapest University of Technology and Economics have undergone a paradigm shift namely had to break away from traditional curriculum and teacher based learning theories and methods and switch over to ICT based atypical learning forms.

This change of attitudes is supported by several possibilities and toolkits such as the following: smartphones, iPads, Kinect interactive units and the games attached to them,

network based web 2.0 services (e.g. joint documents, presentation sharing sites, groups, electronic questionnaires, mobile applications, joint calendars, blogs, social sites, online tests, shared hostings [google], 3d worlds [Leonar3do], virtual environments [Second life]) are playing greater and greater role in the world of ICT based systems and the environment of digital natives (generations of present information society). For the application of these systems and mobile tools it is necessary to obtain the so called “new media competencies”.

### **Methodological application of cloud computing services**

Cloud computing service is a generic term for such services which are provided not on a particular dedicated hardware but in a shared form on several devices of the service provider thus the high availability of divided, redundant servers is provided besides a strong defence against data loss. Cloud computing services appeared in the field of informatics in the 2010's. The number of cloud computing service providers has risen lately, especially in the USA and Western-European countries (Dukan – Kovari, 2013).

The most often mentioned advantages of cloud computing services are their reliable, cost-effective implementation and operation, the fact that 80-90 % of their capacity is utilized, the low requirements of investment and the unlimited computer resource.

The basic feature of cloud computing systems is that their appearance can be changed without any consequence, new opportunities emerge while others disappear or are replaced to provide the best experience and services for users.

Three levels can be distinguished in the field of cloud computing services:

- IaaS – Infrastructure cloud, infrastructure as a service, e.g. Amazon EC2 calculation clusters
- PaaS – Platform cloud, e.g. Google App. Engine which provides a scalable or invisible developer environment. WS-PGRADE is a service of this sort which can be run concurrently and makes possible to access various CPUs
- SaaS – Software cloud, e.g. Auto dock which makes possible importing and monitoring of workflow; WSGgrade/gUSE is known for many users worldwide

Generally speaking, these cloud computing systems strive to make interconnections between various services. This is an essential feature of the system since this way a content created in a particular service becomes available in another and it makes is unnecessary to upload all the data base and information into the new system again (Baróti - Mészáros, 2011).

The most important feature of Open Access is its free availability where application of security protocols is not a requirement. The possibility of collaborative work, continuous data synchronization and data saving, automatic updating, the possibility of sharing contents and encryption of data are mentionable advantages as well.

In the sphere of cloud computing data storage main hosting service providers have come into general use and each of them is connected to some operation platform and works in complete harmony with them. The system of google drive is probably the most often used hosting service provider worldwide in co-operation with android operation system, the second in this rank is the hosting service of Dropbox and its counterpart, the

iOS systems, also Windows phone with One Drive is listed at the third place (Benedek-Molnár, 2014).

Although it does not mean that users can use only the counterpart of the operation system they have. Trello for example is suitable for attaching files stored on Google Drive to particular tasks without the requirement of uploading the file into a cloud again.

As an example for the application of this, the personal homepage of Trello is displayed in the following screen shot.

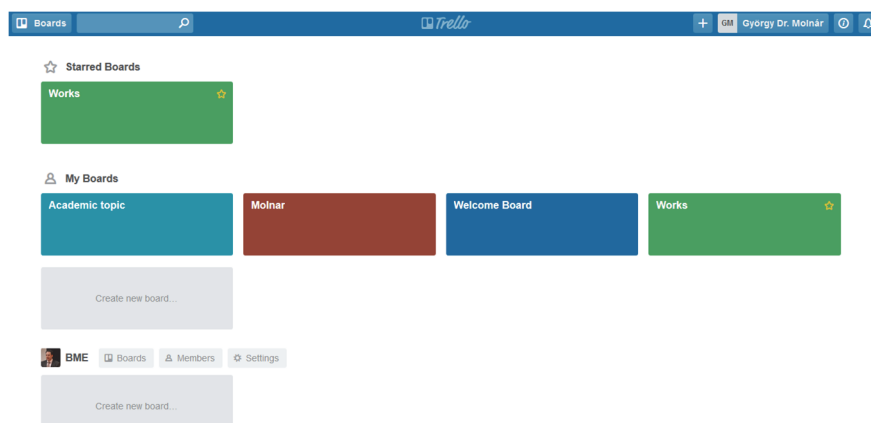


Figure 1: The homepage of Trello, source: own photo

Besides the advantages of cloud computing services there are some doubts about the accessibility and crudeness of the system despite that the growth rate of them will be 4-5 times bigger than the average increase of information technology between 2013 and 2017. The opinions have not reached the point of rest up to now in connection with this.

The most evident example of cloud computing systems is google drive, one of the One drive applications.

Cloud computing services make possible collaborative work in the form of crowdsourcing within a particular project for different users. We could initiate a project to examine this practice. Due to this work we would be able to see the processes, to examine how to make them more efficient and which cloud computing applications can help to complete the task. scratch (<https://scratch.mit.edu/>), a project-based application or learningapps (<http://learningapps.org>) service are good examples for this (Benedek, 2008; Lükő, 2009; Gocsál, 2013).

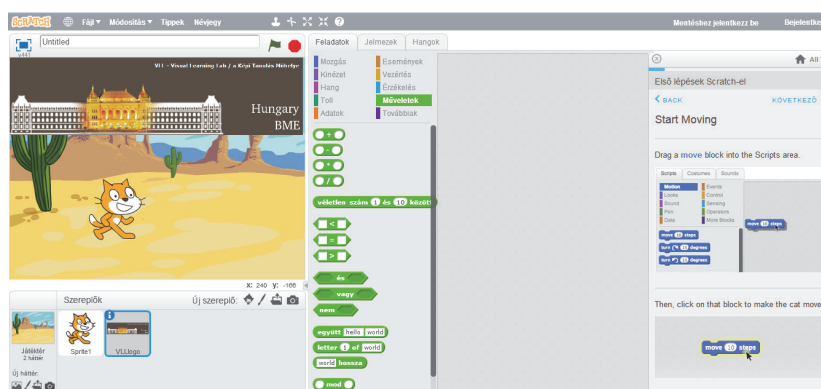


Figure 2: The main page of scratch, source: own photo

## MOOC systems in education

Online teaching which is related to distant teaching and learning has been known for education theories. Nevertheless, the MOOCs (*Massive Open Online Courses*), a complex innovation which developed in the US higher education between 2012 and 2013 - is remarkable and considered as a significant strategic improvement by EUA as well. This innovation represents how the new form of learning with the most progressive „environmental” understanding ever pushes out the traditional frameworks of learning.

From a professional point of view it is especially interesting that new ways of learning have appeared in higher education which is known for its conservative teaching and learning behaviors. It is typical of the new ways of learning to announce courses online, with free (nonformal) joining, putting aside limits of participation, free access, the lack of obtaining credits (which is the most controversial nowadays). We could understand this experiment as a non-formal learning support within the framework of traditional dissemination of knowledge according to the above mentioned characteristics. The fact that the best universities of USA announced the free open courses highly raises its importance and professional value.

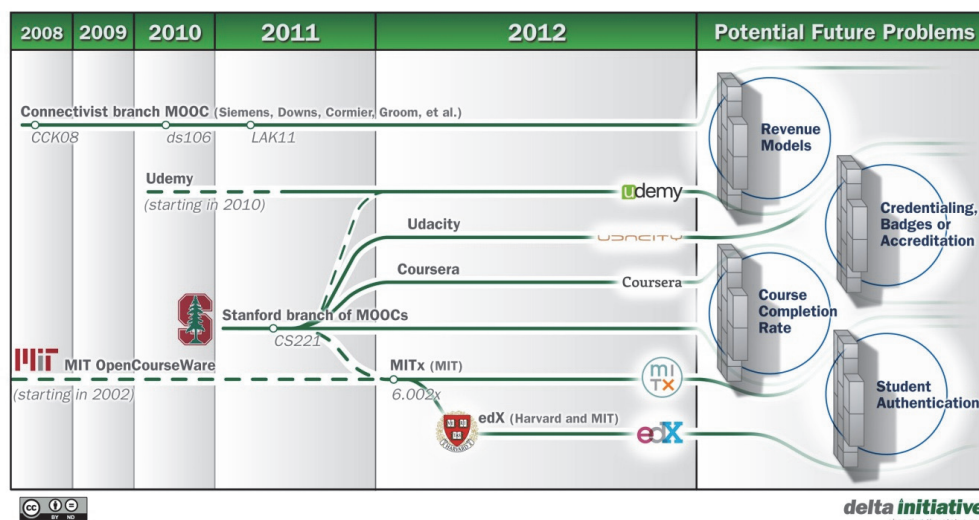


Figure 3: A MOOC timeline 2008-2012, source: Phil Hill, e-literate, 24/07/2012: Four Barriers That MOOCs Must Overcome To Build a Sustainable Model, <http://mfeldstein.com/four-barriers-that-moocs-must-overcome-to-become-sustainable-model/> (downloaded: 2013. 03. 10.)

School, as an institute and a key factor of the educational process is not in an easy situation at all. The so called 2.0 pedagogical paradigm means a new possibility for the 'Net-Generation' that is the generation which knows and uses the Internet as a matter of course in a world where a major proportion of schools and teachers organize the educational process as it was typical in the 20th Century. A lot of institutes of education move behind the fortification of conservatism or react spontaneously and struggle for being successful under new circumstances. Besides the traditional communities, new communities – which are organized very easily – such as Facebook, Twitter, Flash-mob based community activities and these are not only changing our society but means a new challenge in education (Balogh, Munik, Turcáni, 2011).

## Expanded virtual reality and virtual learning environments

Besides Second Life, CloudParty, the virtual environments and learning space with a great past there are the newest technologies which want to visualize real content through special glasses called Oculus for their users. It provides real experience-like due to the 3dimension realistic visualization of contents and the realistic imaging of the movements of head and eyes. A special vizor of this kind is in the following picture.



Figure 4: Oculus, sources: own pictures

The new trends of development attempt to virtualize Facebook – it is called Facebook-Oculus. Users will need only a console, haptic gloves which simulate skin perception and a vizor (virtual reality glasses) for a realistic experience. The idea of virtuality has occurred in the field of education and registration function is accessible on Classroom developed by Google and on Classcraft which has educational functions as well. The following screen capture shows the surface of virtual classrooms.

## EMPIRICAL ASSESSMENT RESEARCH OF ICT ATTITUDE AND DIGITAL COMPETENCES

The research has been conducted by electronic survey in spring 2016 based on simple random sampling; the target group involved full time and part time students studying pedagogy, economics or engineering. The research focused on social media using habits. We got N=122 analyzable answers within the deadline. The survey consisted of 16 closed questions. The main results are as follows.

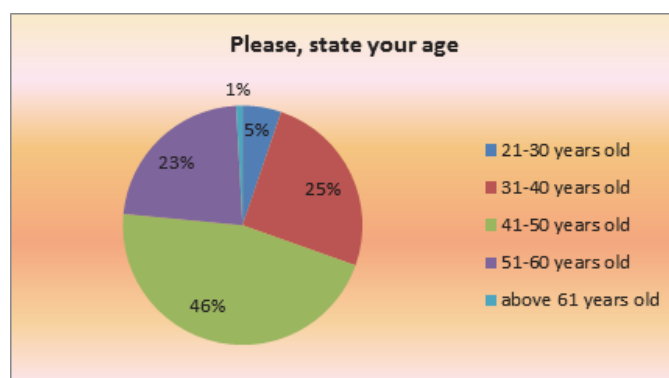


Figure 5: The distribution of age of the respondents, own chart

The next diagram below shows the use of community media. According to it more than half of the students find social media useful in their studies. This shows how much they know and how confident they use these kind of media elements.

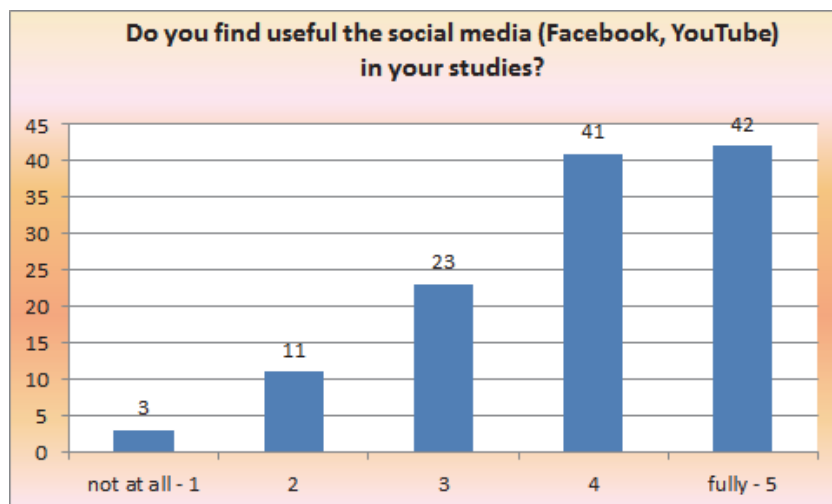


Figure 6: The distribution of social media, own chart

The majority of the respondents community media provides a completely or moderately suitable field for getting information about and discussing various opinions in connection with learning. According to answers, 29 students full, 39 mostly find social media capable of discussing actual teaching and learning issues.

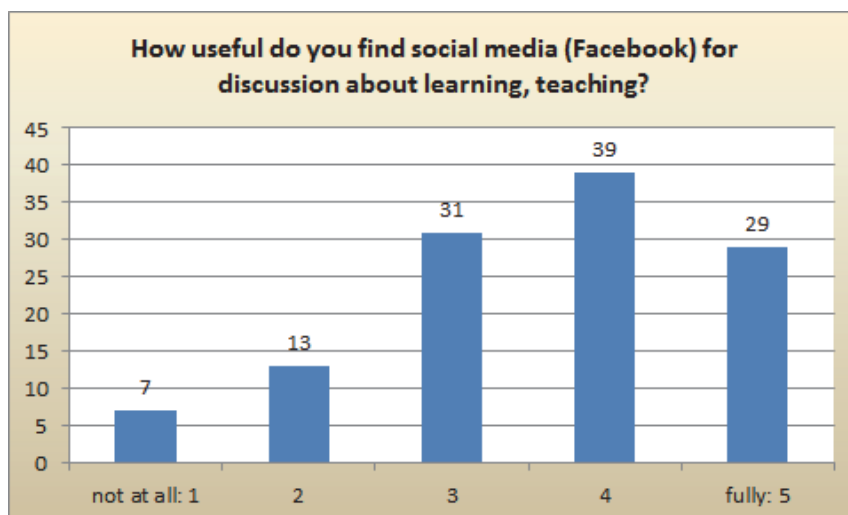


Figure 7: The distribution of useful of the topic of discussing, own chart

Some 60% of the respondents stated daily use in connection with the frequency of social media using habits which is assisted by mobile tools such as smart phones or tablets. 24% percent of students on weekly basis, 7% monthly, while 5% annually use social media. However, there is some 7% that has never used a service like that. Altogether, there is a positive picture about social media use.



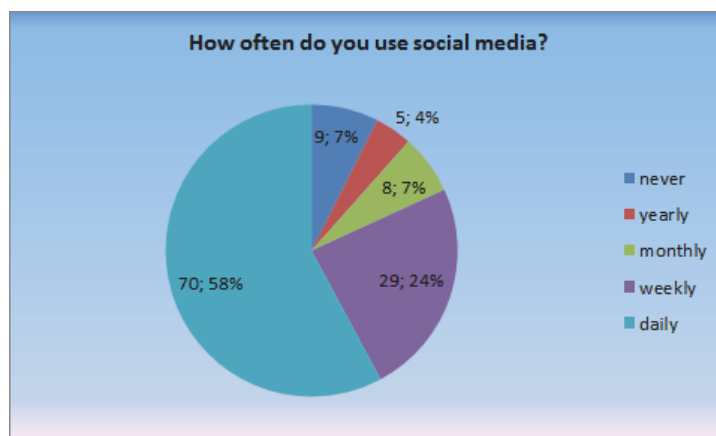


Figure 8: The distribution of timetable of the social media, own chart

In the last chart we can see the types of information related to learning. According to this learning support online contents are at the first place, general news about learning at the second place and feedbacks given in connection with curriculums at the third place, which is a special feature of the new network-based learning theories as well. 25% of the respondents do not share contents of this kind.

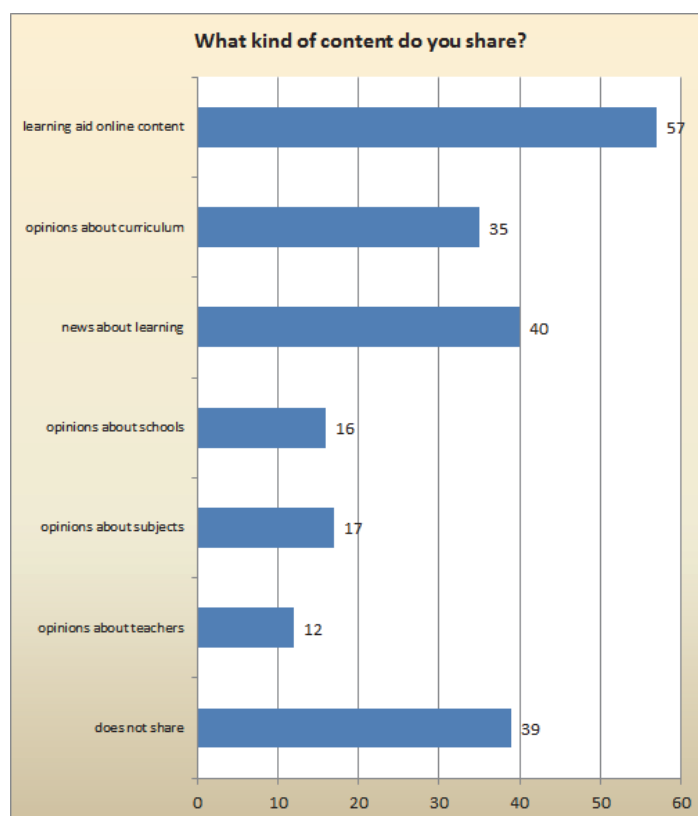


Figure 9: The distribution of kind of content, own chart

## NEW POSSIBILITIES IN THE ICT ENVIRONMENT OF THE FUTURE

Education policy in some countries emphasized adaptive learning support systems which are completely flexible in time and space and are based on intelligent technology. A

good example of that is the Republic of Korea where the government has launched Cyber, a home learning system, software and infrastructure, which improves the quality of public education and smoothes away the differences between private and public schools. The system significantly decreases the cost of education due to the lack of travel costs.

The system provides the possibility of attaining curriculums at home though the internet. It aims to cease the digital gap between primary school and high school in the education system. Cyber home education system operates development diaries, following attendance, and Learning Management System (LMS) used for evaluation, as well. It supports creating experience-based, cooperative learning and enables teachers to provide online support.

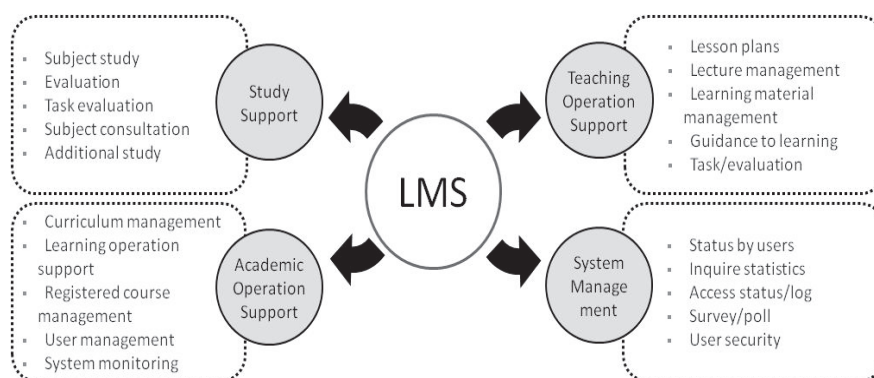


Figure 10: LMS at home, source: own photo

## CONCLUSION

Using social media has become an integral part of our information society, especially those who belong to the digital generation take the opportunity of using it. Nevertheless it is typical of them being online all the time and the immediate share of information, which is generally considered as a positive phenomenon, but they do not really know all the functions of social media and this results in a deficit in their digital competency. Based on the results of the above mentioned empirical researches we can state regardless of age that there is no doubt about the usefulness of social media and that learning related information is shared most often besides general and personal information. Mobile communication tools have greater and greater significance regarding access, positive habits and opinions are dominant in connection with sharing and use.

We should not forget that use of IT/ICT cannot be a substitute for personal interactions rather the supporter, more and more indispensable supplement of it. It provides – in case of suitable application – countless possibilities, experience for teachers and students as well. If it is “tuned” well it is a helpful supporter of self-directed teaching and learning process.

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# Communication in Education: ICT Tools Assessment

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## Abstract

*The article describes some preliminary results of implementation of WorkPackage 4 (WP4) "Selection and testing new IT tools" in frame international research network IRNet and researchers from partner institution from Ukraine, Poland, other countries. This results concerns analyzing and study some category ICT-tools for Communication in education and their assessment. The first part of article includes the theoretical aspects of communication: activity profile, some pedagogical aspects of teaching - learning together. The methods of cooperative learning, some psychosocial characteristics of communication over the Internet, analysing of challenges of communication, barriers of effective communication, model, communication quality requirement, form of communication and other items. Second part of paper described the research conducted in the frame of Module 005 WP4 and includes: Communication tools typology according to education activities, Mixed features of Communication Tools, Efficiency trend for top rated Communication ICT tools. Model 1, Sample expert card, Sample tool expert rating, Final expert ranking of Communication tools (all package period which has been divided on several main stages 1-5). Final part of manuscript contains expert model assessment and conclusions as to the top ranking IT communicative tools of the social media category. The comprehensive profile of social media communication tools in education and research is derived.*

## Keywords

*Communication. Education. ICT tools. Assessment. E-learning. Items of assessment.*

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## INTRODUCTION

Within modern educational paradigm, the 21<sup>st</sup> century skills concept (Abbott, 2013) is motivated by the belief that teaching students the most relevant, useful, in-demand, and universally applicable skills should be prioritized in today's schools, and by the related belief that many schools may not sufficiently prioritize such skills or effectively teach them to students.

The basic idea is that students, who will come of age in the 21<sup>st</sup> century, need to be taught different skills than those learned by students in the 20<sup>th</sup> century, and that the skills they learn should reflect the specific demands that will be placed upon them in a complex, competitive, knowledge-based, information-age, technology-driven economy and society (Suto, 2013).

While the specific skills deemed to be “21<sup>st</sup> century skills” may be defined, categorized, and determined differently, the term does reflect a general—if somewhat loose and shifting—consensus (Cápay et al., 2012). The following list (ibid) provides a brief illustrative overview of the knowledge, skills, work habits, and character traits commonly associated with 21<sup>st</sup> century skills:

- critical thinking, problem solving, reasoning, analysis, interpretation, synthesizing information;
- research skills and practices, interrogative questioning;
- creativity, artistry, curiosity, imagination, innovation, personal expression;
- perseverance, self-direction, planning, self-discipline, adaptability, initiative;
- oral and written communication, public speaking and presenting, listening;
- leadership, teamwork, collaboration, cooperation, facility in using virtual workspaces
- information and communication technology (itc) literacy, media and internet literacy, data interpretation and analysis, computer programming;
- civic, ethical, and social-justice literacy;
- economic and financial literacy, entrepreneurialism;
- global awareness, multicultural literacy, humanitarianism;
- scientific literacy and reasoning, the scientific method;
- environmental and conservation literacy, ecosystems understanding;
- health and wellness literacy, including nutrition, diet, exercise, and public health and safety.

In lieu of the fact that leadership, teamwork, collaboration, cooperation is considered an integral part of the 21<sup>st</sup> century marketable skills scope, **the objective** of this paper is to consider the placement of communicative activities and skills across a comprehensive expertise of required ICT tools in education.

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## COMMUNICATION: ACTIVITY PROFILE

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Collaboration is commonly defined as a conscious process of information transfer between two or more sentient beings with the help of a semiotic system; c In general, communication is a means of connecting people or places (OED, 2015), “To work jointly with others or together especially in an intellectual endeavor.” (WTID, 1993)

In education and business coaching collaboration is referred to as two or more people working together to accomplish some objective, to achieve shared goals (Boston KM, 2014)

It is a recursive (Martinez-Moyano, 2006) process where two or more people or organizations work together to realize shared goals, (this is more than the intersection of common goals seen in co-operative ventures, but a deep, collective determination to

reach an identical objective) by sharing knowledge, learning and building consensus. Structured methods of collaboration encourage introspection of behavior and communication (Spence, 2006). These methods *specifically* aim to increase the success of teams as they engage communicatively in *problem solving*.

It exists in two main temporal forms:

- *Synchronous*, comprising of Same Place <-> Same Time, and Different Place <-> Same Time models;
- *Asynchronous*, comprising of Same Place <-> Different Time, and Different Place <-> Different Time models (Boston KM, 2014).

Principle models and corresponding features of communication are:

1. Same Time, Same Place: Discussion, Brain storm, Communicative skills, Access to documents, Access to educator, Polling, Project/task management, Rosters of multiple types, Calendaring/scheduling
2. Same Time, Different Place: Lecture, Discussion, Workshop, Research, Tutoring, Conference, File sharing, Resources.
3. Different Time, Same Place: Resources, Control.
4. Different Time, Different Place: Message exchange, Review, Assessment, Resources.

Participants of reciprocal educational communication include universities, educators, students. In its turn, student's collaboration environment includes: 1) Students from University, 2) Teaching staff of University, 3) Administrative staff, 4) Experts, 5) Peers, 6)Tutors (MOOC), 7) Family, 6) Employers.

Among the indicators (or maxims) of effective communication are:

- **The maxim of quantity** : one tries to be as informative as one possibly can, and gives as much information as is needed, and no more
- **The maxim of quality**: one tries to be truthful, and does not give information that is false or that is not supported by evidence.
- **The maxim of relation**: one tries to be relevant, and says things that are pertinent to the discussion
- **The maxim of manner**: one tries to be as clear, as brief, and as orderly as one can in what one says, and where one avoids obscurity and ambiguity (Townsend, DeMarie and Hendrickson, 2015).

The given indicators are traced across educational paradigms.

The essentially communicative collaborative approach within the constructivist paradigm was derived by Lev Vygotsky, known for his theory of social constructivism, who believed that learning and development is a collaborative activity and that children are cognitively developed in the context of socialization and education (Greener, 2015). The perceptual, attention, and memory capacities of children are transformed by vital cognitive tools provided by culture, such as history, social context, traditions, language, and religion. For learning to occur, the student first makes contact with the social environment on an interpersonal level and then internalizes this experience.

In terms of this approach, Collaboration at the conceptual level, involves the following traits and features: awareness, motivation, self-synchronization, participation, mediation, reciprocity, reflection engagement.

## **Pedagogical aspects of teaching - learning together. The methods of cooperative learning**

One of the most contemporary and effective methods of teaching and learning is to teach in collaboration or co-operative learning has been described in manuscript (Morze, Varchenko, Smyrnova-Trybulska 2015). Authors stressed that there are many methods of collaboration learning. All of them are based on the creation of a situation in which students work in small groups to help each other learn the given material. Robert Slavin describes the methods. Some of them are presented in Table 2 (Morze et al. 2015), which contains the name of the method, a description of the method (May, Resler-May 2008), and aspects of the use of the method in a virtual team of learners in the LCMS MOODLE system (Smyrnova-Trybulska, 2009; Gutiérrez - Esteban P. et al., 2015). Name of collaborative learning methods:

1. The STAD method (Student Teams-Achievement Divisions).
2. TGT Method (Teams-Games-Tournament).
3. TAI Method (Team Assisted Individualization)
4. The "Jigsaw" Method, Developed by a team of Elliot Aronson
5. Group Investigation Method.

## **Psychosocial characteristics of communication over the Internet**

Being in a virtual reality puts an Internet user in a different situation in which interaction and communication take place in a different way from everyday experience (Morze, Varchenko, Smyrnova-Trybulska 2015). A new quality of the experience is determined by specific characteristics of the virtual space such as (Aouil & Kajdasz-Aouil, 2007):

- 1) *Limited sensory experience*: a virtual environment implies the possibility of contacts based on experience, using the sense of sight, hearing, and the combination of both modalities. Still, the lack of physical contact is an important limitation;
- 2) *The identity flexibility and anonymity*: the lack of direct interactions between users of the Internet results in unusual ideas of self-presentation of conversation participants (study, work). They may, but need not reveal information about themselves;
- 3) *Equalization of status*: the virtual space gives equal opportunity to its users, regardless of their status, wealth and race. In this way the impact on the users of the network depends only on those communication skills, perseverance, and presented its achievements (academic, professional, in other), positions, etc.;
- 4) *Transcending spatial boundaries*: communication via Internet gives you the opportunity to communicate with similar interests and needs no matter where they live, and the distance between them. Bridging distances in a matter of minutes, seconds, building a new world regardless of geographical conditions;
- 5) *Time stretching and condensation*: cyber-space implies the possibility of synchronous communication on the one hand, when many people at the same time participate in the same conversation, the project is finished, etc.;
- 6) *Access to numerous relationships*: with pretty much ease contact you with a substantially large group of people. With advanced search options, filtering, dial becomes effective communication with user-specified individuals or groups;

- 7) *Permanent records*: Virtual communication and knowledge of the Internet can all be documented and stored (for example, for educational purposes);
- 8) *Dreams and altered states* - altered states of consciousness, sitting in front of computer monitor track and "controlling" the reality of the keyboard can experience the compact states on the similarity of dreams. It is probable that this possibility can be - is the cause of some forms of Internet Addiction.

The process of communicating via the Internet is not traditional means of communication. No physical contact between the participants on the one hand will limit the exchange of non-verbal elements of communication, on the other hand the process of releasing a number of restrictions and conditions, such as gender, age, status, time, space on the grid, the level of financial, performance, etc. (Morze, Varchenko, Smyrnova-Trybulska 2015)

Of all the educational paradigms, e-learning and u-learning (Crowe 2007: 129) relies almost exclusively on communicative collaboration as an educational template, skills formation and assessment tool and ultimate objective.

Forms of communicative collaboration comprise of 2 groups:

- 1) Relationship oriented: Affinity networks, Learning communities
- 2) Task oriented: Communities of Practice, Project Communities

According to the authors' estimations and expert assessment, *needs and challenges* of communicative collaboration include the following groups of issues:

1. Geographical:
  - Geographically dispersed teams
  - Sharing information and documents globally
  - Collaboration across time zones and physical locations
  - Sharing creation and access to work products
  - Identifying and accessing external experts and resources
2. Workplace:
  - Workplace with easy-to-use tools
  - Document repository
  - Management tools, including scheduling and task management
  - lists, tables, rosters, tasks, score cards
  - Communication tools, including e-mail, discussions, conferencing, voting
3. Personal:

Team members:

- Access the latest team resources, any time, any place
- Participation in asynchronous, threaded discussions

Team leaders:

- Confidence that all team members would be on the same page
- Ability to stay fully connected any time, any place

Barriers of effective collaboration include:

- No easy way to share best practices



- Insufficient facilities for video conferencing
- Inadequate technology – slow PC and network connections
- Technology overload
- Lack of accessible, effective, credible, local training and support
- Poor behaviors when working as a team (Boston KM 2014):

Needs and challenges of collaboration in an open e-learning environment comprise of the following issues:

- sharing information and documents
- collaboration across physical locations
- sharing creation and access to work products
- identifying and accessing external experts and resources
- classroom with easy-to-use tools
- document repository
- management tools, including scheduling and task management
- lists, tables, rosters, tasks, score cards
- communication tools, including e-mail, discussions, conferencing, voting.

A learner focused quality concept has to be more comprehensive than just focusing on aspects of instructional or technological interface design. This is clearly shown in the results of the survey (Ehlers 2013). Accordingly, communicative collaboration quality requirement can be identified as:

- Social Cooperation:  
The cooperation sequences in the online course should especially focus on the integration of discursive course settings and controversial topics. Not the social aspect is emphasized here but the active knowledge creation in argumentative
- Discursive Cooperation:  
The cooperation sequences in the online course should especially focus on the integration of discursive course settings and controversial topics. Not the social aspect is emphasized here but the active knowledge creation in argumentative

Participants of communication in education are: Universities, Educators, Students. Thus, a student's collaboration environment includes:

- Students from University
- Teaching staff of University
- Administrative staff
- Experts
- Peers
- Tutors (MOOC)
- Family
- Employers

Principle models of communication in education comprise of the following activities:

1. **Same Time, Same Place:** Discussion, - Brain storm,- Communicative skills,- Access to documents,- Access to educator,- Polling,- Project/task management,- Rosters of multiple types,- Calendaring/scheduling
2. **Same Time, Different Place:** Lecture, Discussion, Workshop, Research task, Tutoring, Conference, File sharing, Resources
3. **Different Time, Same Place:** Resource,- Control
4. **Different Time, Different Place:** Message exchange, Review, Assessment, Resources.

## **COMMUNICATION ICT TOOLS EXPERT ASSESSMENT.**

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Communication tools requirements, according to the authours' group estimation, comprise:

1. Type of communication (verbal)
2. Simple interface
3. Scheduling feature
4. File sharing
5. Timing
6. Environment
7. Technical architecture

Among the requirements, the following features have been identified:

- Type of communication (verbal)
  - common
  - conference
  - private
- Simple and friendly interface
  - Intuitive
  - Voice oriented
  - Object oriented
- Scheduling feature
  - Long term project (Gantt chart)
  - workflow
  - Kahnban chart (crucial stages)
  - Brainstorm
- File sharing
  - Video
  - Audio
  - picture
  - Text
- Timing
  - Real time

- Off-line
- Environment
  - Centralized
  - Decentralized

The communication tools, identified for analysis (Hart 2015) have been subjected to typology according to the featured activity profile.

Thus, selected IT communication tools have been identified according to collaboration models:

#### **Same place, different time**

*Academia.edu, Google Search, Pinterest, Khan Academy, Google Scholar, SharePoint, Schoology, Blackboard Collaborate, PaperRater, Google Classroom, Schoology, Poll Everywhere, Udemy*

#### **Same place, same time**

*Skype, mural.ly, <http://www.draftboardapp.com/>, MindMeister <https://www.mindmeister.com/ru>, Socrative, Adobe Connect, Diigo, SharePoint, Evernote, Cloud, wiki, Google Classroom, Lectora Inspire, Wordle*

#### **Different place, same time**

*blogs (blogspot, twitter, tumblr), social networks, Trello, WordPress, Scribblar, LinkedIn, Kahoot, Yammer, Blackboard Collaborate, writing.com, Red Pen (Criticism) <https://Redpen.io/>, Google Doc, WordPress, Kahoot, Scoopit*

#### **Different place, different time**

*Cloud, wiki, Academia.edu, Google Search, Pinterest, Khan Academy, Google Scholar, SharePoint, Schoology, Blackboard Collaborate, PaperRater, Google Classroom, Schoology, Poll Everywhere, Udemy*

The second major Collaboration tool typology has been conducted according to identified prominent education activities (Table 1):

Table 1. Communication tools typology according to education activities (Source: authours' group study)

COLLABORATION ACTIVITIES	COLLABORATION TOOLS
Composition	Cloud, wiki, Google Classroom, Evernote, Lectora Inspire, Wordle
Storytelling	Writing.com, Google Translate, Scoopit, Haiku Deck, Wordle
Presentation	Google Classroom, Google presentation, Go Visually, YouTube, Prezi, Pinterest, Adobe Connect, Udemy
Problem solving (project, applied task)	Scribblar <a href="http://www.scribblar.com/">http://www.scribblar.com/</a> , Conceptboard <a href="https://conceptboard.com/">https://conceptboard.com/</a> , Trello <a href="https://trello.com">https://trello.com</a> , Team Gantt <a href="http://teamgantt.com/">http://teamgantt.com/</a> , Dropbox, Padlet, Socrative, Adobe Connect, Edmodo, Nearpod, Blackboard Collaborate, IFTTT, Poll Everywhere
Assessment of object or process according to criteria	PaperRater, Google Classroom, Schoology, Poll Everywhere, Udemy
Peer review/evaluation	writing.com, Red Pen (Criticism) <a href="https://Redpen.io/">https://Redpen.io/</a> , Google Doc, WordPress, Kahoot, Scoopit
Brain storming, problem solving, argumentation	mural.ly, <a href="http://www.draftboardapp.com/">http://www.draftboardapp.com/</a> , MindMeister <a href="https://www.mindmeister.com/ru">https://www.mindmeister.com/ru</a> , Socrative, Adobe Connect, Diigo, SharePoint, Evernote
Composing a bibliography	Cloud, wiki, Academia.edu, Google Search, Pinterest, Khan Academy, Google Scholar, SharePoint, Schoology, Blackboard Collaborate
Communicative skills	social networks (Facebook, Academia) , blogs (BlogSpot, Twitter, Tumblr) Scribblar, WordPress, LinkedIn, Kahoot, WhatsApp, Yammer, Socrative, Adobe Connect, Scoopit
Role fulfillment	blogs (BlogSpot, twitter, Tumblr), social networks Trello, WordPress, Scribblar, LinkedIn, Kahoot, Yammer, Blackboard Collaborate

A total number of 242 of Communication and Remote collaboration tools have been analyzed by the authors' group, chosen out of the Top 100 Efficient Learning Tools ratings (Hart 2015).

Of them 47% prove to be of the mixed type, featuring indicators of Communication and Research activity tools (Cf. Figure 1):

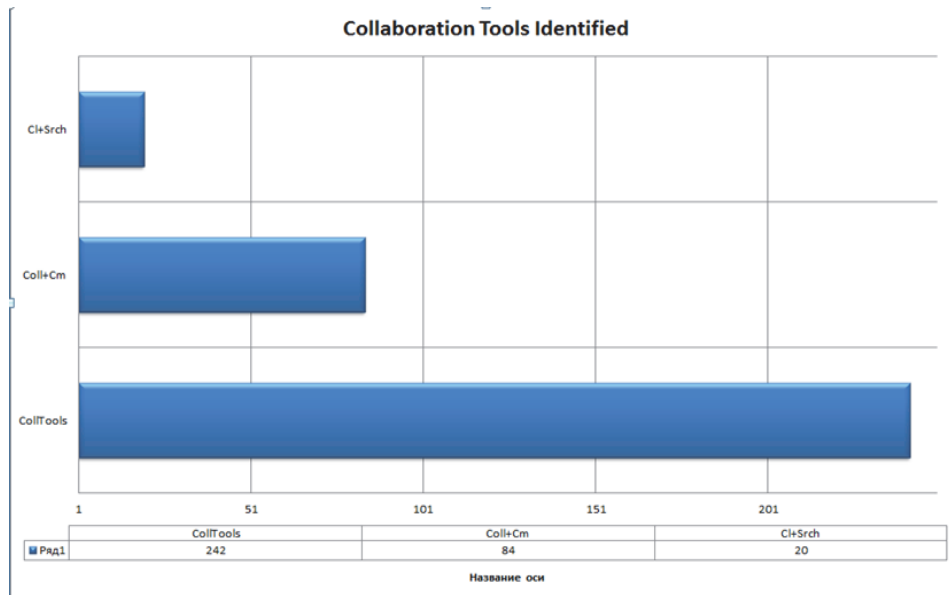


Figure 1 Mixed features of Communicative collaboration Tools (Source: authours' group study)

The efficiency trend for top 16 rated Communication ICT tools for the recent 3 years (2013-2015) acquires the following dynamics (Figure 2-3):

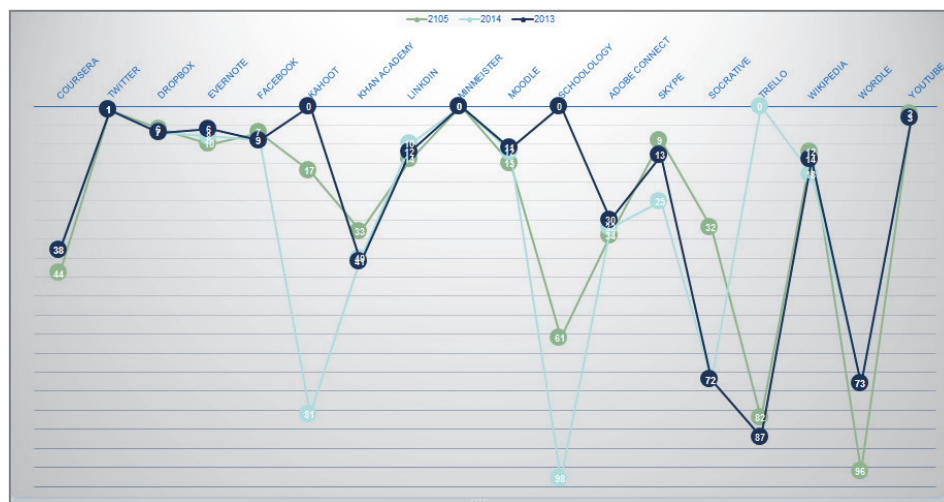


Figure 2 Efficiency trend for top rated Communication ICT tools. Model 1

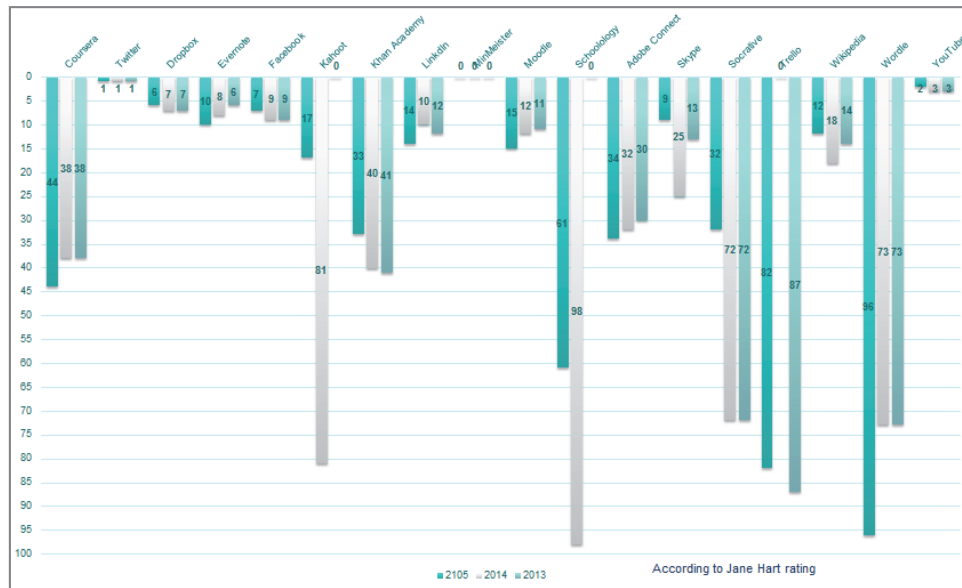


Figure 3 Efficiency trend for top rated Communication ICT tools. Model 2 (Source: authours' group study)

The diachronic dynamics indicates the drastic increase in social media and network technologies as a type of Communication and Remote Collaboration tool in learning (ranking points 1, 3, 6 and 7 accordingly across the sampled time-span).

The highest ranking Communication tools identified include:

1. Social networks
2. Blogs
3. Skype
4. Writing.com
5. Mind Miester(mind maps)
6. Scribblar
7. Google Classroom
8. Trello
9. Google presentation
10. You Tube
11. Adobe Connect
12. Red Pen
13. Evernote
14. PaperRater

The identified Communication tools have been subsequently subjected to independent expert evaluation according to the adhering to the Customer Satisfaction Evaluation model (Dos Reis 2015), featuring the efficiency per education activity as a main criterion (Cf. Figure 4)

COMMUNICATION ACTIVITIES	COMMUNICATION TOOLS															
	Skype	Adobe Connect	Google Classroom	Google Doc	Google presentation	Google search	YouTube	Evernote	Writing.com	Scribblar	Trello	Mind	Mistier Social networks	Blogs	Red Pen	PaperRater
Composition	3	4	5	5	5	1	4	3	5	5	5	5	5	5	3	2
Storytelling	3	3	4	3	4	1	3	3	4	4	3	4	5	5	2	1
Presentation	3	4	5	4	4	1	4	1	3	4	3	3	5	4	2	1
Problemsolving (project, applied task)	4	4	3	3	2	1	2	3	4	4	3	3	5	4	3	1
Team building	5	4	4	3	2	1	2	3	4	4	4	3	5	4	3	2
Peer review/evaluation	4	2	4	5	2	1	3	3	5	4	3	3	5	5	4	4
Brain storming, problemsolving, argumentation	5	4	3	5	3	1	3	4	4	4	4	4	4	5	2	1
Role fulfillment	5	4	4	1	3	1	4	2	4	4	3	3	5	5	4	4

Figure 4 Sample expert card (Source: authours' group study)

The total number of 7 anonymous independent experts have been featured in Communication tools assessment. Each tool has been rated according to each activity efficiency estimation (see Figure 5):

N o		Experts opinion Classify 1-5									
	Social networks	1	2	3	4	5	6	7	Su m 1- ..	coef ficie nt	Toal sum x coeff
1	Composition	5	5	5	2	5	5	5	32	0,91	29,26
2	Storytelling	2	3	5	2	4	5	5	26	0,74	19,31
3	Presentation	4	4	5	1	5	3	3	25	0,71	17,86
4	Problem solving (project, applied task)	3	4	5	4	4	4	4	28	0,80	22,40
5	Assessments of object or process according to criteria	2	2	4	2	4	5	5	24	0,69	16,46
6	Peer review/evaluation	5	4	5	1	4	5	5	29	0,83	24,03
7	Brainstorming, problem solving, argumentation	4	4	5	4	4	5	5	31	0,89	27,46
8	Composing a bibliography	1	1	4	1	3	4	4	18	0,51	9,26
9	Communicative skills	5	5	5	5	5	5	5	35	1,00	35,00
10	Role fulfilment	4	4	5	5	5	5	5	33	0,94	31,11

<b>Total n° of points</b>	<b>23,21</b>
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Figure 5 Sample tool expert rating (Source: authours' group study)

The rating coefficient has been calculated as a  $\sum$  of points per activity divided by 35 = (7x5) => 7 experts, 5 points total per each activity.

The final expert ranking of Communication tools under consideration is as follows (Table 2):

Table 2. Final expert ranking of Communication tools (Source: authours' group study)

No	Tools	Points
1	Social networks	23,21
2	Blogs	21,05
3	Skype	17,61
4	Writing.com	17,41
5	Mindmeister (mind maps)	16,81
6	Scribblar	16,74
7	Google Classroom	16,49
8	Trello	15,75
9	Google presentation	14,55
10	Youtube	14,27
11	Adobe Connect	13,8
12	YouTube	11,86
13	Evernote	11,04
14	Red Pen	11,01
15	PaperRater	6,15

## CONCLUSION

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According to expert model assessment – the top ranking communicative tool falls into the *social media* category (23,21 points). The *social network* engines are designed to store, share, promote, reference and review academic output. The network type interface is designed to facilitate students' and researchers 'personal collaboration, navigation through the thematic span of academic output, uploaded into public domain.

The major purposes of this collaboration tool include:

- store
- share
- interact / network
- review
- disseminate
- upgrade
- rate
- learn
- charter a comprehensive, customized reference stock of one's research and/or education interests

A social network interface comprises of the following elements:

- a personal profile (photo, basic personal data, interests, CV)
- an upload service to store one's work by type (books, papers, drafts, pictures)
- a newsfeed featuring recent uploads filtered by stated interests complete with bookmark service

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# Identification of Criteria Measuring the Value of Knowledge: A Text Mining Study

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## Abstract

*At present, it is important for corporations, investors, and lenders to understand the critical factors affecting the value of companies. It is important because of decisions regarding investments and loans, which all companies must make in pursuit of innovation and progress. The knowledge economy is more developed and the traditional methods of creating firm value have been transferred from physical assets to intangible assets (intangible knowledge). For this reason, the measurement of investments and the valuation of intangible assets, subject to review, have become critical for future economic development. This study uses the method of text mining, which is mostly used in the context of unstructured data sources such as scientific articles, review studies and excerpts from books. On a selected set of 106 cells, this method uses the Statistica 12 programme. These 106 articles were selected from an original set of 385 articles, scientific papers and surveillance studies. The search was carried out in the usual search engines, which led to the initial selection of 385 articles (1990-2015). Text-mining techniques have been applied in order to find the relevance of the themes linking domains which evaluate investments and knowledge. Analysis has been performed using a synonym dictionary. This procedure has been useful in identifying relationships between terms and a combination of elements, allowing one to explore hypotheses concerning research directions. In order to confirm the results, the close interdependence between these domains and finding the determinants of the articles were reviewed, to verify the output of the text mining.*

## Keywords

*Knowledge. Measurement. Intangible assets. Text mining. Investment. Data. Information.*

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## INTRODUCTION

Currently, in a knowledge-based economy, companies need to pay ever greater attention to skills acquisition, expansion, transfer and the use of knowledge. Traditional methods of measuring the value of enterprises that were used to examine the physical factors of production, have been transformed into the exploration of intangible assets. Given these facts, so a large part of the value of a company is now reflected in its intangible assets. Financial indicators and statistics do not sufficiently reflect the value of a company and its intangible assets (Gilaninia, Rankouh and Dastoor, 2013). The current situation displays fewer controls, regulations and disclosure of information in this area. This creates a gap in information between the internal and external environment of companies (Vergauwen, Bollen and Oirbans, 2007). Companies need to measure their

investments in intangible assets in order to assist with investment opportunities, lending decisions and many other aspects. Using metrics, the company could more accurately and efficiently determine a reliable valuation of its intangible assets and predictive models (Thorleuchter and Van den Poel, 2012).

Many researchers are trying to describe and define the most crucial components of intangible assets, which affect market value (Spahic, 2014). There is, however, a single direction using insight and metrics that would solve this problem. A general understanding of the composition of intangible assets is already clear, however, and explained in a considerable number of publications. Intangible assets and tangible assets should be associated with the creation of the real market value of a firm. However, the value creation of tangible assets is obviously easier to identify than the value generated by intangibles (Han and Han, 2004).

On the other hand, some advanced models for evaluating the learning outcomes as results of the educational process have been created. In addition to the most traditional ones based on didactic tests, approaches by Bradáč (2014) using fuzzy logic and rule-based expert systems, Balogh and Turčáni (2011) using IF-THEN rules and fuzzy Petri nets or Janáková (2014) using swarm optimization methods could be introduced as the most innovative ones. Unfortunately, even these methods do not solve the problem of evaluating the knowledge assets. According to our best knowledge, no general model of evaluating investment in intangible assets - knowledge - has been developed.

The objective of the paper is to lay down the grounds of such a model by determining the most frequently occurring terms in connection with the evaluation of investments in knowledge. These terms are intended to then be used as indicators for the evaluation of investment in knowledge and for proposing recommendations for practical use. For this purpose, an analysis of articles from scientific databases in the period 1990 – 2015 was considered. Together, this data base (text base) includes about 385 articles, from which only 106 were selected for analysis by the text mining method.

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## **METHODS**

### **Sample of the text documents**

For the analysis, we limited the text documents to the ones indexed in world-wide scientific databases such as Scopus, ISI Web of Knowledge, ProQuest or ScienceDirect. The queries for searching the articles were as follows: (measurement of Investments OR measuring of Investments OR Investment) AND ("knowledge" OR "intangible assets" OR "intellectual capital" OR "knowledge discovery" OR "knowledge management" OR "knowledge mining" OR "knowledge-based system"). The articles were selected according to predefined keywords and from 1990 - 2015.

All documents are presented in English. For further processing, they are converted to txt format to be processed smoothly by the software. The first step was selecting scientific papers selected from online search engines. They were scholarly articles which have a range of about 10 pages. They discuss the effectiveness of investment in knowledge. It is necessary to choose the right extensive articles, going beyond the concept of knowledge, and somehow simply explain investment in knowledge, having already evaluated their effectiveness. After this preliminary assessment, roughly 385 articles were selected. 106 of them were selected for final analysis and text miner analysis. A secondary reason for this

was the inability to analyse the numerous articles which were not available for download or copy.

## Software

We used the software **Statistica 12** (Data Miner / Text Miner) from StatSoft (currently under Dell), which provides a basic installation of an optional expansion module named simply STATISTICA Text Miner. The analysed documents can be preprocessed before indexing takes place, with indexing occurring alone or simultaneously with it. In the process, the rules on exclusion of the word - stop list may be applied. It is possible to manually create and use the built-in event promotion of the language. The software also uses other algorithms for text editing, specifically stemization. Fortunately, thanks to the aforementioned stemization, the programme can be successfully applied to other languages. The **TAGUL** programme was used to create a word-cloud fence of keywords relevant to the study. The word-cloud plot, as seen in the results chapter, is the software tool author which creates the preference or importance in these newly and continually created keywords.

## Advance preparation of the text for subsequent analysis (text mining)

Converting to a single format. It is necessary to eliminate the documents in PDF format, which, due to the use of various open source tools for export from the original format (probably doc. or rtf.) will produce considerable fragmentation in the coding. When using the software Statistica 12, documents that include accents may suffer from those letters with accents being replaced by nonsensical characters. It is therefore necessary to eventually remove these accents (one step) and also convert these documents into a workable form for the text miner. Further conversions are performed through the SW NitroPro 10 (freeware tool) for nitropropane documents, whose articles are converted flawlessly to plain text, txt., This is the most favorable for Miner processing of text articles. Statistica 12 shows the processing of plaintext as by far the most preferable that it can process, compared to other types of files. These documents were completely ready for import into the text mining software.

## Text mining for the literature review

For manual analysis, 106 articles is a relatively large quantity. In this study, organized information was used for analysing the literature. The aim of the analysis of text mining in Statistica 12 was configured for the measurement of investment in knowledge and finding the determinants of these investments. The aim was also to limit the scope of our expressions and it made sense to define a vocabulary that includes terms for the common measurement of investment and terms that appear in association with knowledge and knowledge management. This procedure is simpler than having TM algorithms search groups of words and count words indiscriminately. For this reason, the thesaurus scope was defined as being composed of one or more words. For text mining, the Statistica 12 programme was used. Furthermore, the TAGUL programme (open-source tool) was used to create a Word-cloud plot, which graphically displays textual data. This was typically used to display key metadata. In this case, the Word-cloud plot shows words under the cumulative frequency of words in a given number of documents where they occurred.

## Preparing of text mining SW

### Stop list

To eliminate irrelevant words, it was necessary to add a stop list, which is an integral part of the analysis. Otherwise the programme would not eliminate irrelevant words from the analysis and, ultimately would create false results. The Stop list can be searched freely online, or is already a part of the programme (Statistica 12 includes a stop list in English). It is possible that in some cases it may be necessary to expand on some words. This may be caused by the nature of the analysed sample.

### Creating a frequency dictionary and thesaurus

The creation of a thesaurus is needed because the Text Miner sometimes needs to have certain synonyms predefined (especially in a foreign language). A frequency dictionary is not always entirely necessary. Many programmes which contain stemmization, can work even with foreign words (Moro, Cortez and Rita, 2015). The text miner scans selected articles to find the most frequent words. Some of these words are eliminated and transferred to a stop list. For all other words, the thesaurus should find a few alternatives (synonyms). In these cases, only a thesaurus is created and a frequency dictionary isn't needed. After stemmization and completion of the text corpus, we can proceed to build a text-document matrix. Our thesaurus was created on the basis of the selected words after the first results of text mining. The first thesaurus contained around 140 words, but as it turned out, only 31 words were sufficient for the final analysis.. For the analysis of the selected texts, three methods were used. These methods are: clustering of words, word tracking method and frequency analysis of texts.

### Clustering method and frequency analysis

Many authors use different words and phrases to describe the concepts. It was necessary to merge these words with identical or similar occurrences into small groups. Stemmization and lemmatization are the easiest ways of clustering words. In this study, we have used stemmization owing to the Statistica 12 programme, stemming truncated words to their radical form so that score, scoring, scored, or scores were turned into 'scor'. Think of stemming as linguistic normalization. In the process of stemmization, the morphological information of some words may be irretrievably lost. Despite these minor shortcomings, stemmization was performed in this research. It can be easily extended with a thesaurus, however, the thesaurus does not contain only synonyms, but antonyms, hyponyms/hypernyms, meronyms/holonyms and more. (Chen, Shie and Yu, 2012). There are other methods under stemmization which can be used as alternative methods of clustering words. For the selected words, it is possible to visualise the structure of the text corpus (Jong-Min and Sunghae, 2015). The aim of **frequency analysis** is to find the most frequent words and then to assign these words to the topic to which they usually belong (Jong-Min and Sunghae, 2015).

## RESULTS

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The first results of the analysis in the Statistica 12 programme were only for illustrative purposes and for orientation in the articles. Further, the first step was used to verify the suitability of the selected articles. The results are presented in two parts. In the first part, the results were analysed on the basis of the frequency matrix for all 106

articles. The relevant results are shown in Table 1. The second part of the study was focused on the importance given to stems and selected words. The documents used were optimally prepared as the process only took a few minutes. After completing the analysis, a table appeared with the results. The table shows the number of documents analysed (106), the total number of keywords (1000) and the total number of synonyms (33125) as shown below.

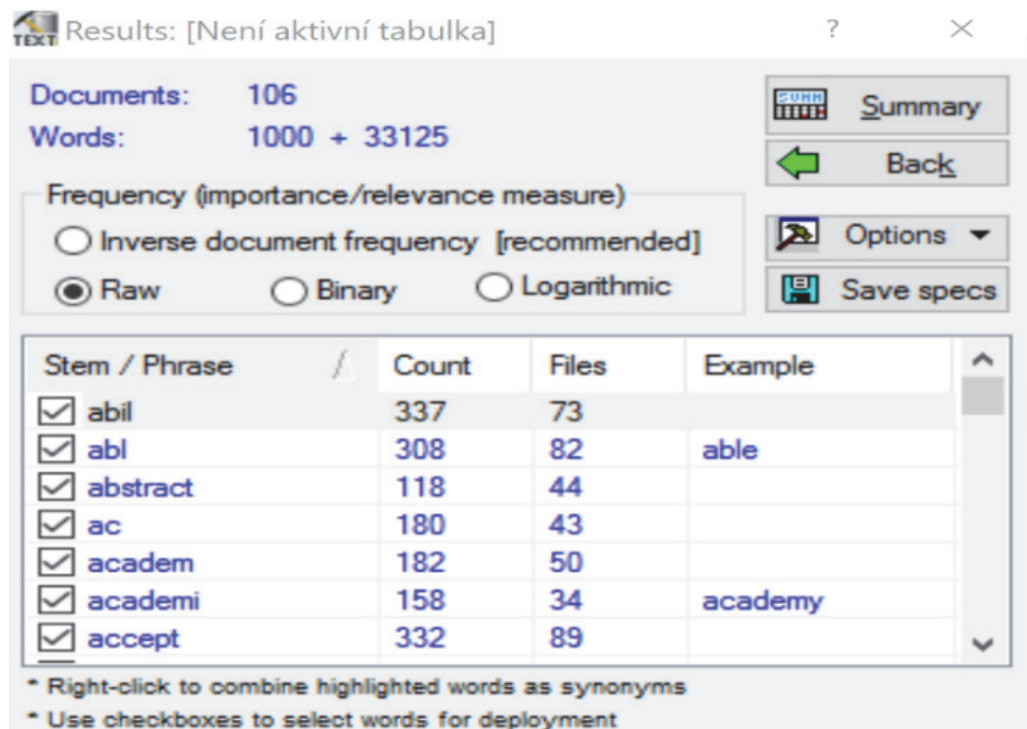


Figure 1: Indexing of text in Statistica 12

Figure 1 shows these stems, their number in documents, the number of documents in which these stems were found and examples (synonyms). It was necessary to work with the results and then to find the optimal results. From 1000 keywords, 149 stems were selected, from which the final outcome was 47 stems that occurred in more than 67 papers and their occurrence ranged from 946 to 15 431. In this way, other expressions, that were irrelevant to the study were removed. It was also necessary to adjust some shortcomings in the SW with the thesaurus. In the Statistica 12 programme, there is an option to combine individual words as synonyms. This option was used to select words assigned to one main word (synonym). The best display is a statistical representation under the function “selected words” as shown below in Table 1.

Table 1: "Selected words" in Statistica 12

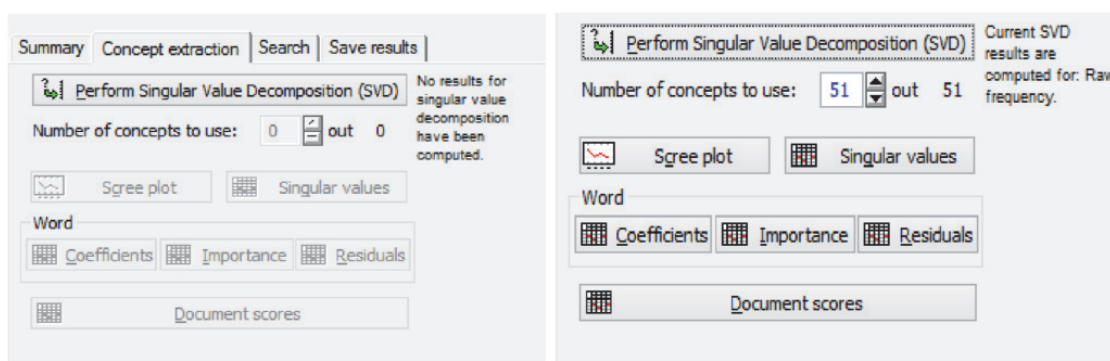
Stem/Phras	Number of documents	Number of occurrences	Stem/Phras	Number of documents	Number of occurrences
analysi	101	1934	level	97	1417
approach	97	1051	manag	95	3973
base	97	1655	market	70	1580
capabl	67	952	measur	98	1844
case	97	969	method	100	1574
compar	99	1154	model	98	3306
data	101	2712	need	92	1006
design	88	1281	number	94	1062
develop	101	2536	perform	88	2235
effect	97	2606	posit	86	1018
employ	100	4896	process	95	2220
factor	98	1523	research	100	3116
group	89	1008	resourc	78	1000
hypothesi	100	2326	result	100	2086
impact	84	996	scienc	99	2455
implic	96	1071	share	77	1240
includ	97	1216	show	98	1127
increas	97	1170	social	79	1746
indic	93	946	system	102	5494
inform	94	1935	use	100	4020
invest	86	1682	valu	97	1495
knowledg	102	15413	variabl	83	1664
learn	83	1133	work	96	1335

A further useful display, along with the function "selected words" is "indexed documents".

This also comprises the largest amount of meaningful information. For each document, the length and content keywords are shown. E.g. the first article from Agostinho, et al. (2015) had a length of about 102,250 characters and contained 1595 keywords. On the processing results card of the analysis are a few functions of data mining. Most of them in terms of text mining are not interesting until we reach the function "Importance".

	File summary ((Není aktivní tabulka))				
	Document length	Number of words	Word 1	Word 2	Word 3
Agostinho et al. - 2015 - Towards a sustainable interoperability in networked enterprise information systems Trends of kn	102250	1594	model	inform	system
Aliyu et al. - 2015 - An overview of current knowledge concerning the health and environmental consequences of the Fukushima Daiic	130925	1306	factor	review	manag
Allal-Chérif, Makhlouf - 2015 - Using serious games to manage knowledge The SECI model perspective-annotated.txt	34568	690	research	research	use
Apak, Atay - 2015 - Global Competitiveness in the EU Through Green Innovation Technologies and Knowledge Production-annotated.	33284	507	social	scienc	manag
Aragón Sánchez, Sánchez Marín, Mueses Morales - 2015 - Gestión del conocimiento y resultados empresariales efecto mediador d	77546	1809	effect	resourc	practic
Araín - 2015 - Knowledge-based Approach for Sustainable Disaster Management Empowering Emergency Response Management Ti	35299	772	design	manag	approach
Battke et al. - 2016 - Internal or external spillovers—Which kind of knowledge is more likely to flow within or across technologies-ann	112012	2026	research	research	extern
Beckmann, Stix - 2015 - Foreign currency borrowing and knowledge about exchange rate risk-annotated.txt	111406	1160	employ	employ	manag
Behringer, Sassenberg - 2015 - Introducing social media for knowledge management Determinants of employees' intentions to adopt	46354	945	research	report	social
Biron, Hanuka - 2015 - Comparing normative influences as determinants of knowledge continuity-annotated.txt	57432	1087	inform	manag	inform
Boon Sin et al. - 2015 - Structural equation modelling on knowledge creation in Six Sigma DMAIC project and its impact on organiza	96638	2124	employ	employ	structur
Brundage et al. - 2015 - Energy economics in the manufacturing industry A return on investment strategy-annotated.txt	48802	814	employ	return	invest

Figure 2: Indexed documents in Statistica 12



The function of “Importance” is to create a vector model document. The document is understood as a vector. Each keyword describes the content of the document and reflects its importance.

	Term-document frequency matrix																		
	1 accumul	2 acquir	3 achiev	4 aim	5 analysi	6 appear	7 approach	8 approxim	9 assess	10 asset	11 attribut	12 balanc	13 base	14 calcul	15 capabl	16 capac	17 capit	18 captur	
1		1	3	2	20	1	27		2	1			15	1		15	2	1	3
2	3			1	2	10		7	4	32		2	19	8			1		
3		2		3	4	11		6		2	2		7	1		2		1	2
4	1			3	3	4	3	2		1	1		5			1		5	2
5		3		5	1	20		9		5	7	1	8			2	3	6	1
6	1	1	2			6		13		5	1		21			4	2	1	
7				5	58		10		3	2			1	10		3	2		
8	1			1	1	10		2		4	2		1	10		1			
9				2	13	1	3		1	7			1	2		1		1	2
10	1	3			8		1		3	3		1	6	1		2	2	2	3
11				10	4	31	2	8	1	9	5	1	25			13	2	1	1
12				2		27		1	3	3			8	12			7		
13																			
14	1			2		2	1	3	1	2	3		3			2		4	5
15				12	1	10		23		7	4	1	1	11		1	6		
16					5	12	1	2	2	21			6	1			1		
17		1		3	3	28	1	100		6			27	5					2
18		1		7	5	24	6	11		15	6	3	1	22	1	2		11	1
19				7	4	29	2	17	1		1		4	13	5			1	1
20		3			1	33	1	18		6	2	1		7		5	51	9	
21		1			1	38	7	2		2	1		2			3	14	9	
22				2	4	33		17		2		2	9	6		1	1		
23			2		2	21	3	4		9	2			13	1	8			1
24	3				2	5		1		1		2		1	1			14	
25	23			4	2	9	2	3		4	20	2	19	3	8	3	14		

Figure 4: “Term-document matrix” in Statistica 12

The Term-document matrix displays the frequency of occurrence of the stems.

## Word-cloud plot



Figure 5: “Word-cloud plot” in TAGUL



12 of the most important and appropriate terms for the study were chosen. The concepts are presented in their original version and these terms were: knowledge, process, method, invest, data, inform, increase, show, model, social, include, compare.

## **DISCUSSION**

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The analysis of the literature in this study focused on the main issues of investment in knowledge and the evaluation of these investments. This study is a good starting point for further research by the author in terms of finding the determinants of evaluating the investments in knowledge. The study, which examines the two disciplines of the banking sector and business intelligence, and also uses the method of text mining, is authored by Moro, Cortez and Rita (2015). The authors selected the articles from the peer-reviewed journals on the basis of BI applications, business, and management in the last few years (2002-2013). The crucial difference was in the selection of only 14 journals from the databases of scientific papers. By contrast, in this study, a much higher number of magazines was selected. Another major difference was the use of different specific software and dictionaries of synonyms. In the context of the results, the authors focused on the selection of areas where BI applications and banking were most frequent. Since 2009, the boom in the area of research has been as in this study. It is possible, as the authors state, that the reason is the financial crisis in 2008.

Another inspiring study was on "Graphical casual inference and the regression copula model for apple keywords by text mining" from the authors Jong-Min and Suanghe (2015). The authors also looked at the keywords, but already pre-selected for a specific company (Apple). They reached conclusions on technological trends and their relationship with Apple technologies. This research could help in the search for new technological areas and central planning technology for Apple's research and development. This study is only intended to point out any deficiencies in current literature and gaps in the assessment and measurement of investment in knowledge. The main authors, who were the inspiration for this author, are Tsai, et al. (2016) and Massingham (2014). These two authors focus on the assessment of knowledge and knowledge management. They are professionals who also worked for consultancy companies such as KPMG. Tsai, et al. deals mainly with using the methods of data mining and text mining for the evaluation of knowledge and intangible assets.

At the beginning of the analysis, the intention was to find the most common words which occurred in chosen text documents. However, for the purpose of research, it is obvious, that the term associated with the evaluation of investments in knowledge, will not be most common. At first sight, this study has some limitations, which offer opportunities for further research and improvements. The first limitation certainly is the subjective selection of articles before any analysis. The second limitation is that the study focuses on finding the appearance of concepts evaluating investments in knowledge and the measurement and evaluation of these investments. Many authors focus more on the transfer and sharing of knowledge, and not knowledge measurement. When some authors have already engaged in measuring investment, they have applied research through case studies in selected companies and selected samples of employees of certain companies. But the problem of case studies is precisely that they deal only with such model situations, for example, in a model firm, country or another set of data (objects). Through the analysis of text documents, 12 key concepts were selected that were the most represented in documents and had the greatest predictive value for the further sorting

and examining of text documents. The analysis shows that the most important concept is knowledge, which is logical and correct when we are examining the articles that should be targeted in the evaluation of knowledge and its measurement. The biggest boom in publishing scientific papers began around 2009-2010 with its main theme being investment evaluation and the measurement of investment in knowledge or knowledge transfer.

## **ACKNOWLEDGEMENTS**

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The paper is supported by the grant project of the Internal Grant Agency of the FEM CULS Prague "Knowledge engineering methods in the process of evaluating employee knowledge", No. 20161026, and by the grant project of the Internal Grant Agency of the CULS Prague "Innovative approaches to the use of ICT in education for the mitigation of social exclusion", No. 20151007.

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# Use of Computer Simulation in Learning Process

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## Abstract

*Models and simulators are one of the forms of digital technology, which supports the learning process. A model enables learning through discovering and the construction of hypotheses. The hypotheses can be subsequently verified due to the possibility of working with simulators and observing the behaviour of modelled objects and their mutual relationships. As a result, the acquired knowledge can be accommodated into the learning structure of an individual. The paper demonstrates the possibilities of constructivist instruction in the field of astronomy aimed at the relative movements of the Sun and the Earth. The simulation of a planetarium in the environment of the Stellarium computer program enables the creation of didactic situations in which students learn about their naïve pre-concepts. In the Stellarium environment, students can observe and verify these pre-concepts from various points of view – as inhabitants of the individual planets of the Solar System or as outside observers. The rooted knowledge (pre-concepts) and the inability to approach it from different points of view need to be overcome through a conscious activity and consistent observation in the Stellarium environment. Experiments and various measurements can be conducted in the environment, which leads to the acquisition of data that can be used for further processing and verification of the established hypotheses. In order for the reconstructed and newly created pre-concepts to be real and true. Observation of the movements of celestial bodies helps develop students' spatial imagination. Moreover, working in the virtual planetarium environment contributes to the development of an algorithmic approach to problem solving.*

## Keywords

*Computer simulation. Teaching. Information processing. Algorithmic thinking.*

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## INTRODUCTION

Integration of information and communication technologies (ICT) into education and the related transformation of school are phenomena of our time (Kalaš et al., 2013). In schools, digital technologies are used in a variety of forms (Kapounová and Pavlíček, 2002). Digital content can be made available through an e-learning platform, interactive whiteboard or mobile touch devices (Kostolányová and Klubal, 2015). The use of robotic toolkits (Oujezdský and Nagyová, 2015), remote and virtual laboratories (Schauer, Lustig and Ožvoldová, 2009) or technologies for data collection and processing directly in the field (Šnajder and Guniš, 2015) is less frequent.

The purpose of the use of digital technologies in the education process is their ability to not only provide information, but also to process, present, forward and archive it in a

suitable manner. Working with information is common to all forms of digital technologies. Besides the mentioned digital technologies, also computer models and simulations can be used for working with information (Hubalovský and Hubalovská, 2014).

The paper is aimed at the use of a virtual simulator of a planetarium in the environment of the computer program Stellarium in a constructivist-oriented instruction. The simulator enables the creation of didactic situations aimed at observing the movements of celestial bodies and conducting accurate measurements of their current position in the sky. Consistent and accurate observation enables learning through discovering (see e.g. Papert, 1980; Papert, 1986) and the formulation of primary hypotheses which need to be verified.

In order to acquire data about the phenomena observed in the Stellarium environment, suitable scripts, which enable the recording of data into a file, need to be defined on the basis of the established algorithms. Data acquired from the measurement can be further processed in the MS Excel spreadsheet environment. The results acquired from the conducted analysis will help students reconstruct their rooted pre-concepts and formulate new knowledge.

Working in the environment of the Stellarium virtual planetarium is aimed at the support of instruction of the so-called STEM (Science, Technology, Engineering and Mathematics) subjects (Beňačka, 2014). It is based on the exploratory approach to problem solving and presents various attributes of science work – observation, formulation of hypotheses, drawing conclusions, etc. Work does not require a deeper knowledge in the astronomy field.

## **STELLARIUM COMPUTER SIMULATOR**

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Stellarium is a computer program, i.e. a virtual computer planetarium (Stellarium, 2016). It displays a realistic 3D sky as the naked eye or a telescope sees it. It comes in a version for all common PC platforms but also in a form of a mobile application, which makes it possible to observe and measure outside, in a real environment.

Stellarium is user friendly. An easy menu makes it possible to set basic parameters – current time and a place of observation. Any place on the Earth or any place in the Universe (planets, stars, etc.) can be selected as a place of observation. The switch buttons are used to set the necessary displayed data such as names of the celestial bodies, constellations, ecliptic plane, etc. The movement in the virtual simulator and zoom in or out of the observed objects can be intuitively set using the mouse.

### **Becoming Acquainted with Stellarium Environment**

At first, the Stellarium environment is unknown to students. Moreover, they are not familiar with the relationships between the individual celestial bodies, particularly with the hidden manifestations of the movement of celestial bodies, and as they may be seen from the Earth or different parts of the Solar System.

Solving simple tasks will help students set basic parameters (location, date, time), find celestial bodies and the movement of the sky. Besides the working techniques, we select the tasks in a way that would enable students to discover movement patterns of celestial

bodies (from the known to the less known), from the more difficult to the less difficult tasks.

### Task 1:

At what time did the Sunrise in your city this morning? At what time will the Sunset? At what time will the Moon rise and set? At what phase is the Moon and is it be possible to observe it during the night? If so, at what time?

In order to solve the task correctly, it is necessary to set the location parameters. This can be achieved either by determining the current GPS coordinates (e.g. on Google Maps) and inserting them into the Stellarium environment or by finding the closest location in the program list. Furthermore, date and time need to be set. The time of sunrise and sunset is determined by the continuous setting of time while observing the Sun in the sky. One will subtract the time when the Sun appears on/disappears from the horizon.

The Moon parameters can be calculated in a similar manner. The phase of the Moon and other information can be determined by highlighting the Moon (see Figure 1).

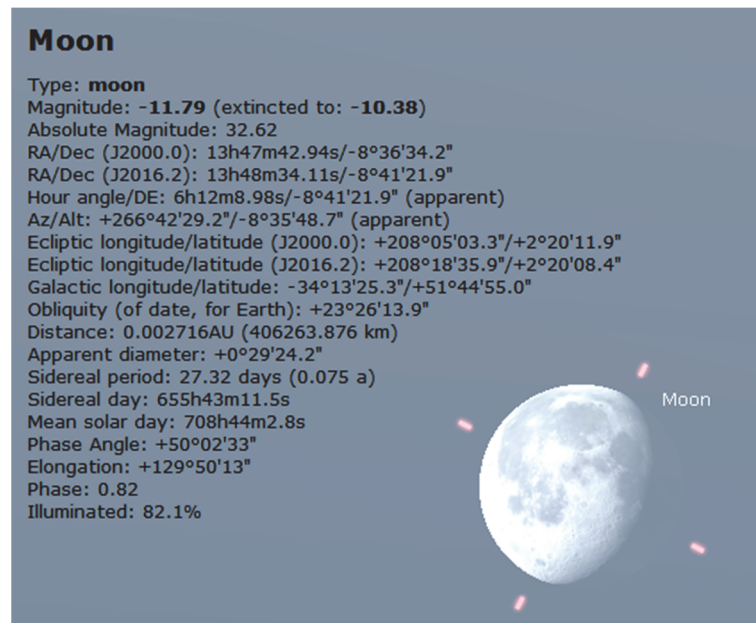


Figure 1: Moon Parameters as Displayed in Stellarium

*Note:* At first, students find this task demanding. They need to understand the basic context – the need to determine the place of observation, date and time. The actual solving process is not difficult. Students should prepare a simple table (a worksheet) in advance for recording the determined data. The exploratory approach can be supported by recording the position of the Sun and the Moon for different places in the world and their comparisons – where the Sun rises and sets sooner, where the day is longer, whether or not the phases of the Moon differ, etc. We will encourage students to formulate their own hypotheses and help them with their verification.

### Task 2:

Different things are said about the movement of the Sun across the sky on the southern hemisphere. Let's try to verify them. Determine in which way the Sun moves

across the sky on the southern hemisphere from dawn to dusk. Compare the appearance of the Moon in the individual phases on northern and southern hemispheres and draw a conclusion about the change of the Moon phases.

*Note:* Discussion about the known differences in the movement of celestial bodies on northern and southern hemispheres can be used as a motivation to solve the task. Students' assumptions and knowledge can be verified in the Stellarium environment. The main differences are in the left side and the right side. Therefore, it is necessary carefully observe the movement of celestial bodies (the Sun and the Moon) from left to right and vice versa as time goes.

### **Task 3:**

Every day, the Sun moves along its arcuate path from East to West. At Christmas, the South Pole experiences polar day. What is the path of the Sun across the sky on the South Pole in 24 hours?

Everybody has encountered the term polar day in school. However, hardly anybody experienced it – during the day the Sun never sets and orbits the sky around a circle. This phenomenon can be simulated in the Stellarium environment through the animation of the movement of the Sun. The animation can be performed through the Stellarium tools – through an accelerated playback of the situation at a given location.

### **Task 4:**

Is Venus Phosphorus or Vesper?

The task enables students to focus on other celestial bodies – planets, stars, constellations, etc.

## **MEASURING AND RECONSTRUCTING COMPLEX MOVEMENTS**

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A relatively high accuracy of Stellarium allows for a variety of measurements (as the first astronomers). The values do not need to be subtracted by the sextant or focused by the telescope as they can be easily subtracted in the program environment. The first phase is aimed at the observation and measurement of the movement of basic celestial bodies (the Sun and the Moon) when seen from the Earth. Today's instruction of Physics focuses on Kepler's Laws and gravity laws and the description of the Solar System as a whole. The regularities of the movement of celestial bodies when seen from the Earth are relatively unknown.

In order to proceed to the following steps, it is necessary to become acquainted with the basic terminology. The position of celestial bodies when seen from the Earth is determined by the azimuth and altitude. Both quantities are expressed in degrees. The measuring of the azimuth and altitude of the Sun throughout the year determines the difference between summer and winter in the sky. At the same time, it can be seen that at noon the Sun deviates from the South (the deviation changes throughout the year).

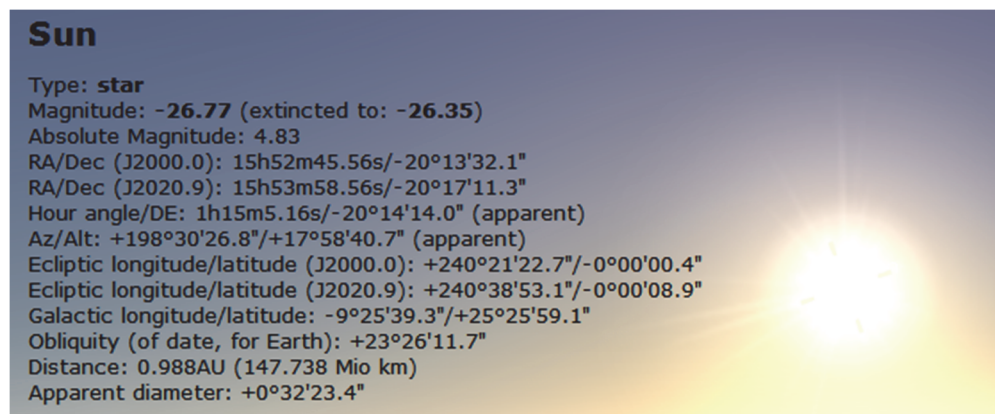


Figure 2: Sun Parameters as Displayed in Stellarium

## Manual Data Collection

We are determining the position of the Sun in the sky throughout the year at noon. We set the time parameters and record data about the position of the Sun on particular days of the year into an MS Excel table. In Stellarium, the data are expressed in degrees, minutes and seconds (see Figure 2, parameter Azimuth/Altitude). Therefore, for further processing, they need to be converted to a proportional part of degrees (a decimal number) when being recorded into the table. Experience shows that it is enough to record the data once in every five to seven days (see Table 1).

Table 1: Table of Manually Collected Data

Date	Azimuth (°)	Altitude (°)
1.7. 2015	212,6172	59,9916
6.7. 2015	212,617	59,99165
11.7. 2015	211,925	59,68028
16.7. 2015	211,1844	59,20198
21.7. 2015	210,434	58,55684
26.7. 2015	209,6997	57,74923

The recorded data for a period one year lead to the following questions: When in the year is the Sun at its highest point at 12 p.m.? When, on the other hand, is it at its lowest point? Is the change of the altitude throughout the year regular or does the altitude of the Sun change at different speeds?

We will insert the data in an XY graph. The curve named Analemma is the result of the measuring conducted in the Stellarium environment (see Figure 3). The curve reminds of the tilted number eight.

## Stellarium Scripting Language

The Stellarium environment offers the possibility to create and start simple scripts. The Stellarium scripting language is similar to the Java language. Among the demonstration scripts, there is a script for a computer simulation of the Analemma depiction which gradually, in a cycle, adds five days to the start date (July 1st, 2015) and in an one-second interval depicts the current position of the Sun in the sky – see the sample of the program code.



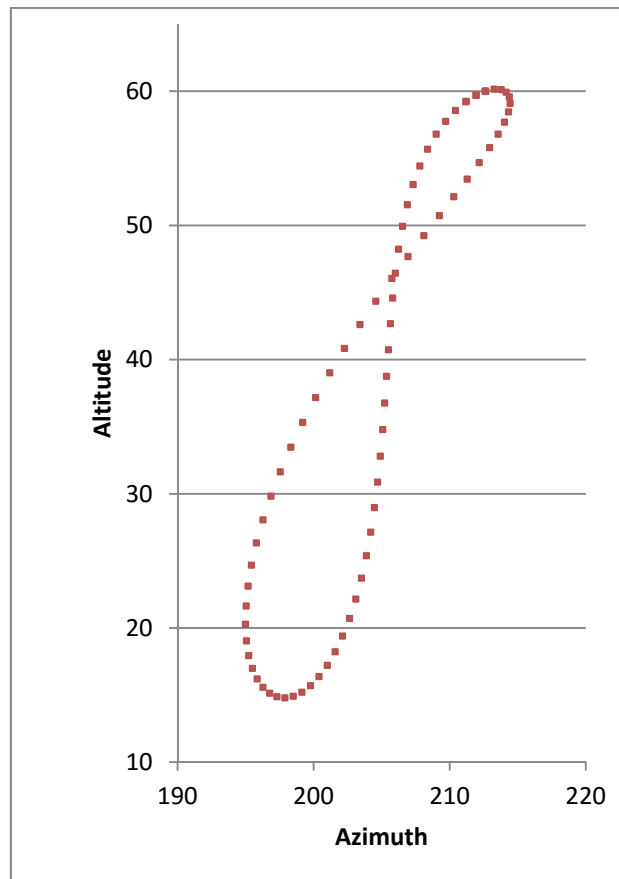


Figure 3: Analemma – Graphical Representation of Collected Data

```
for (i=0; i<78; i++)  
{  
  core.setDate("2015-07-01T12:00:00", "utc");  
  j = i * 5;  
  core.setDate("+ " + j + " days");  
  core.wait(1);  
}
```

The computer animation of the movement of the Sun will confirm the measurements from the Stellarium environment. The acquired information leads to further questions: On which days does the Analemma intersect in the middle? How does the Analemma change with the change of the latitude, i.e. moving to the North or to the South? What does the Analemma look like on the Equator? Is there an Analemma on the Pole and what does such a curve look like?

A number of questions points to the impossibility of manual measuring. The scripts in the Stellarium environment enable an automatic collection of data and recording of both the azimuth and altitude of the Sun over the horizon into a structured file. The program code needs to complement with commands for the recording of necessary data into a file.

```
core.setObserverLocation(18, 0, 1, 1, "", "Earth");  
core.setDate("2015-07-01T12:00:00", "utc");  
core.selectObjectByName("Sun", true);  
core.wait(1);  
core.debug("Info for Sun (SUN)");  
for (i=0; i<78; i++)
```

```
{  
    core.setDate("2015-07-01T12:00:00", "utc");  
    j = i * 5;  
    core.setDate("+ " + j + " days");  
    info = core.getObjectInfo("Sun");  
    out = "Date:" + core.getDate("utc") + "\tAltitude:" +  
        info["altitude"] + "\tAzimuth:" + info["azimuth"];  
    core.debug(out);  
    core.wait(1);  
}  
core.debug("End of data");
```

Before the start of a cycle, it is necessary to set the current place of observation – position on the Equator ( $0^\circ$  latitude and  $18^\circ$  longitude). Furthermore, we set the time of the observation and the observed object – the Sun. Every five days, the cycle determines the current position of the Sun in the sky at 12 p.m. and records the azimuth and altitude data into a predefined log.txt file. The created file is formatted to be opened and worked with in a spreadsheet. There, only an XY graph needs to be created and the parameters of the X and Y axes set. Figure 4 shows how the Analemmas change with the latitude.

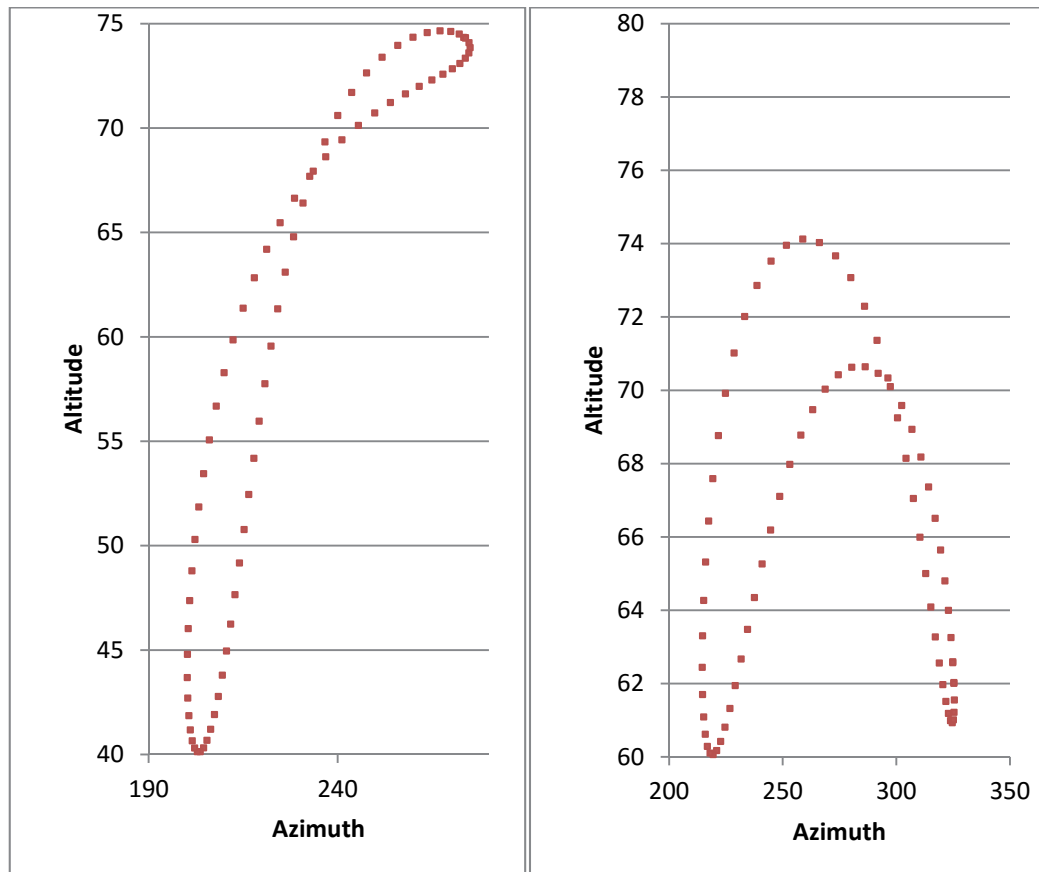


Figure 4: Analemmas – Left on the Tropic of Cancer, Right on the Equator

The change of the appearance of the Analemma from the Equator to the Poles leads to further questions: In which way does the Sun move along the Equatorial Analemma? Where on it are the solstice and equinox points? If it is possible to describe the individual Analemmas in detail, another question arises: How does the Equatorial Analemma

gradually become the Octal Analemma known from the Tropic of Cancer to the North? Do the Octal Analemmas also change when moving toward the Poles?

Finding answers to the questions leads students to the creation of a computer simulation (animation) which can capture the changes. By this time, motivation is no longer an issue as students are enthusiastic about the work. Compared to the manual recording and calculation of data, this procedure appears to be quick and simple. Students can easily agree that each of them will create three analemma graphs for three different latitudes. They agree on the format of the X and Y axes, which will remain untouched during the course of the animation. As far as the actual work is concerned, there are minor problems with the conversion of the data to a spreadsheet and with the construction of a graph related to the representation of the data. The images created in the classroom can be easily combined into the resulting GIF animation.

## CONCLUSION

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The Stellarium virtual planetarium is an important tool in learning by discovering and in the construction of knowledge according to Papert's idea "learning by doing". Working in a virtual simulator enables experiments, measuring and recording various data, which can subsequently be processed in the spreadsheet environment. This process leads to the formulation of hypotheses and small "scientific" theories, which can be immediately verified in the Stellarium environment. The acquired information often leads to further questions and the formulation of further statements.

Students without deeper knowledge in the astronomy field can encounter similar situations to those the old astronauts experienced when discovering the Universe. This way they learn about the principles of scientific work during which they gradually build the entire theory about Analemmas (see STEM instruction). Moreover, they also learn how to formulate and solve problems using the ICT, and not only as individuals but as a part of a team. Compared to the astronomers of old, students can use the computer simulation. What the astronomers were discovering and measuring for centuries, only building correct assumptions, students can see and learn through the use of digital technologies, particularly the animation – be it in the form of a running script or in the form of a GIF animation, which they created on the basis of the data recorded by Stellarium.

Becoming acquainted with the movements of celestial bodies helps students develop their spatial imagination. Moreover, working in the Stellarium environment contributes to the development of an algorithmic approach to problem solving. Despite the initial problems and students' lack of interest in working in a virtual planetarium, the unknown field of astronomy appears to be suitable for working with students' rooted pre-concepts. A reverse confrontation with real situations in the Stellarium environment and the experience of building a system of knowledge when working on a particular project leads to the reconstruction of students' own pre-concepts and to the subsequent accommodation, i.e. the creation of new schemes, which are in accordance with the new information and knowledge.

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# On the Possibility of Solving the Problem of Automatic Generation of Images in Quiz Questions

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## Abstract

*The on-line quizzes with automatic evaluation are priceless assistant in the process of the student's knowledge examination. The images as part of question text or answers in options of multi-choice questions are very useful descriptive tool of examined problems. The preparation of such figures that corresponds with question text is time consuming process. The automatic generation of such questions including randomly generated figures could be the solution of this problem. In the paper we present some ideas for automatic generation of quiz questions that include the automatically-generated variants of images. The generated image can be a part of the question assignment and/or the generated images can represent the correct and incorrect answers in form of various modifications. We identified several partial sub-problems to be solved when generating such questions containing randomly generated images, and we suggested some possible ways of solving these problems by entering constraints limiting certain parameters of the image. In the final part of the article we presented two particular examples of generating the questions containing images. The first example shows the generated image as a part of the basic text of the question. Both correct and incorrect variants of answers to the question represented by different modifications of an image are shown in the second example.*

## Keywords

*Automatic generation. Randomly generated images. Quizzes. Questions with images. Management Science.*

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## INTRODUCTION

An important part of teaching process in any course is the student's knowledge examination. It seems to be suitable to use the examination quizzes for large groups of students when oral examinations may consume too much time. The greater objectivity is an advantage of using quizzes as all students have the same questions or the same type of questions. The comparison of their knowledge level can be more accurate this way. It is impossible to use other forms of examination sometimes, especially in distance learning.

The need for a large number of variants due to copying and spreading the used test questions and answers to the questions by students can be seen as a disadvantage of using

quizzes in comparison with oral examinations. Some students even learn the answers by heart without understanding the problems.

The solution may be the automatic generation of questions with randomly generated input parameters. This way we can even create a unique set of questions for each student. The automatically generated questions can also be used for students of the distance learning with the aim of self-testing and practising any required topics. This topic was discussed and presented in our previous paper (Problems of automatic generation of questions for the purpose of testing the knowledge in a management science course, 2014) as a case for the management science quizzes. When examining the students' knowledge in certain areas of studied issues it would be useful (and sometimes necessary) to use an image in the formulation of test question. If it were possible to generate randomly some modifications of a particular image it would be possible expanding the bank of questions for the generation of quizzes significantly.

The aim of this article is to show the automatic generation of quizzes expanded to include the automatically-generated variants of images. In particular, we will show a possible way of inserting the modified images into individual questions based on the randomly generated input parameters. The generated image can either be a part of the basic questions or it represents the correct and incorrect answers in form of various modifications.

## **THEORETICAL BACKGROUND AND LITERATURE REVIEW**

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We can use a number of up-to-date technologies within the framework of the teaching process at schools, designed for both the face to face learning and the distance learning, e.g. (Kapusta, et al., 2009). The automatic generation of questions for quizzes using a bank of questions is one of quite popular technology in examination e.g. in mathematics. In this case the questions are created from the templates with randomly generated input parameters. In contrast to tests with open-answer questions the use of multiple-choice tests has become a common approach nowadays especially for mathematics (Snajder, et al., 2008). In general, the bank of automatically generated questions can be generated in different ways. In recent literature we can find approaches using both the declarative programming (Prolog) as well as non-declarative programming languages for creating questions in mathematics.

Declarative programming is used e.g. in (Pinto, et al., 2007), (Snajder, et al., 2008), (Xiao, 2001) (LeActiveMath, 2004) (PmatE, 1980) where the systems that provide multiple-choice tests for mathematics are proposed. Tomas and Leal (2013) presented an application of constraint logic programming to create multiple-choice questions for math quizzes. In their AGILMAT system there are two components – an expression generator and an exercise generator, and a solver. The grammar for the expression generator was proposed by Tomas and Leal (2002). The solver includes buggy algebraic rules that translate the well-known common errors.

There are other e-learning tools that use the buggy rules for creating exercises. For instance the reasoner for symbolic differentiation SLOPERT, developed in Prolog, was used by LeActiveMath and MathBridge (Goguadze, 2011) (Zinn, 2013).

Some authors do not use the declarative programming. A technical report of Fikar (2007) presents automatic generation of quizzes using MATLAB system and XML for generating quizzes in a course of Control Engineering. The MATLAB system is also used by Gangur (2011) for automatic generation of questions in a course of Financial Mathematics.

As mentioned above, there are a number of articles dealing with the problem of automatically generating test questions in the available literature. However, in the vast majority, these test questions and answers associated to them contain only text or mathematical expressions. In some cases, these questions contain the graphical components also, but usually in the form previously entered images only. A question into the generated test is then chosen together with the relevant image from the preformed bank of questions.

However, only very few articles addressing the problem of automatic generation of questions containing images that have been modified in various generated variants of the same question. This issue is addressed in the work of Ugurdag et al. (2009) partly. Authors generate multiple choice questions in process of image modification with help of developed graphic tool. In this case new values of parameterized questions are not generated automatically. Liao & Ho (2011) when generating test used the so called image processing function. This function can combine objects through image processing technique according to the rules defined by test editors. Besides, this function can make subtle changes to the size and position of each object to make the best combination for an effective item. Even in this case, however, we are not dealing with the real generation of graphical objects of the same type having different partial characteristics.

The authors of this article are not aware of the fact there has been any article published dealing with the problem of automatic generation of different variants of images in quiz questions of the same type. Therefore, in this article we will show a possible way to generate automatically a number of variants of images based on preset parameters and rules for the purpose of quizzes generation.

## **PROBLEMS OF AUTOMATIC GENERATION OF IMAGES IN QUIZ QUESTIONS**

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As we have mentioned above, we can find a lot of works in the recent literature dealing with the problems of automatically-generated questions for quizzes compilation. Most of these approaches are based on the pre-prepared bank of question. The questions with randomly generated input parameters can be used for students both to generate examination quizzes and to practise e.g. through automatic created self-tests.

In our previous paper (Problems of automatic generation of questions for the purpose of testing the knowledge in a management science course, 2014) we presented the solution of some specific problems not solved by other authors when preparing the bank of questions as a case for the management science quizzes. The main problems concerning the subject of automatically generated questions with randomly generated input parameters which can be used for practising the quantitative (e.g. linear programming) models building are as follows:

- there is usually more than one correct model for the same task;



- the issue of how to check the correctness and functionality of the resulting model;
- the issue of how to generate the models with a feasible solution;
- the issue of how to invent the plausible wrong solutions for the objective functions and constraints.

There are other specific problems to be solved if we want to insert images into the randomly generated questions. Also in this case it is naturally desirable that the same image has not been inserted into the certain question in different instances always. It is necessary that the image will be modified when the same question is included in a next generated quiz instance. However, the logical sense of the question must be retained and the modified image must conform to the text of the question.

There are several types of problems in management science where it may be advisable to include certain type of image to the quiz questions, such as questions concerning the two-dimensional linear programming models, basic terms of graph theory, basic inventory models etc., see e.g. Plevný and Žižka (2005) or Anderson, Sweeney and Williams (2011).

In principle it is possible to distinguish two principal cases of questions with generated images based on random input parameters:

1. the **image is a part of the basic text of the question**;
2. different **modifications of images represent the correct and incorrect variants of answers** to the question.

Of course there may be even questions involving both of the above cases of the image use, i.e. the generated image is a part of the basic text of the question, and at the same time the correct and incorrect variants of answers to the question are represented by different modifications of an image.

Let's analyze initially the first of the two aforementioned basic cases, i.e. the image to be included in the text of the question. This is only possible if we are able to describe parametrically the desired image attributes which are the subject of the randomly generated modification. Those are achieved using parameter values, including defined allowable range of these parameters. This part is not very easy and requires certain experience.

Consideration should be given to the solution of subsequent partial sub-problems:

- a) A **sufficiently simple image** is necessary to be used with clearly definable parameters that will be subject to random generation.
- b) A problem of **generating the input parameters randomly** has to be solved. With the simple random generating of parameters it is highly possible to obtain senseless or to the question inappropriate image.
- c) At the same time it is necessary to solve the problem how to check the **correctness of the resulting image** in context of the text of the question.

In addition to the above, in case we require that various image modifications represent the individual variants of the correct and incorrect answers it is necessary to solve another partial sub-problem:

- d) The problem of *inventing the plausible wrong solutions* to the multiple choice question must be solved, i.e. the problem of designing and automatic generation of the images representing the correct and wrong answers. The randomly generated input parameters of the input text must be also respected when formulate the possible answers.

Unambiguous instruction for solving all the above problems formulated by points a) to d) is unknown to us. We have tried here to show the fundamental problems only to which attention should be paid when formulating the questions intended for the bank of questions in which it is appropriate or even necessary to use an image. At the same time we also identify some possible ways of solving these problems by entering constrains limiting certain parameters of the image. We can limit these parameters e.g. by specifying the value range, requiring the integer values only etc. Nevertheless, the selected method of solving has always to be chosen with regard to a specific task.

In the next chapter we will show two particular examples of generating the questions containing images. These examples include both the above principal cases, i.e. the generated image is a part of the basic text of the question (Example 1), and the correct and incorrect variants of answers to the question are represented by different modifications of an image (Example 2). Both these examples were generated by a generator implemented and tested in Matlab system. Each figure is generated according to specification of the solved task. The different tasks demand unique function and unique algorithm for figure construction (Gangur, 2011).

The output of generation process is saved in the universal XML format. This format allows the XSL transformation to different required formats according to developed XSL templates. In this way the system output can be used for different systems and different purposes. We developed three XSL templates that we used for the generation of the final format. One of them is the Moodle XML format used for electronic testing in the LMS Moodle. In the same way other two templates for the LaTeX and AcroTeX quiz format are used and then a final PDF (interactive PDF) quiz is generated from these outputs. The quiz is prepared both as a teacher version (with results) and a student version.

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## SPECIFIC EXAMPLES OF SOLUTIONS TO THE PRESENTED PROBLEMS

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### Example 1 - Feasible region of the LP problem

The first example presents a case of question with generated image based on random input parameters as a part of the question assignment. The aim of task is assembling the linear inequations that describe the figured polygon. Some of the possible randomly generated polygons can be non-convex. In such case the correct answer is "None of the above" (wrong answers). The key method of the generator consists of the following functions:

```
function [polygon,convex] =  
    Generate_polygon(n,max_coordinates,convex)
```

The function generates coordinates of  $n$  vertexes of the polygon with respect to input constrains (i.e. maximal range of coordinates, integer non-negative values of coordinates). These constraints partially solve the above mentioned sub-problems. The vertexes of the

polygon are generated as closest integer points to points on basic polygon circle. This circle radius corresponds with maximal coordinates value constraint. The points on circle are computed from randomly generated angle in selected arc. The arcs guarantee required minimal length of polygon sides. The output of this function is a polygon represented as set of points (vertexes). If the input parameter `convex` is set to `false`, the non-convex polygon is generated. In such case the convex polygon is generated firstly, and then some of vertexes are moved closer to the centre of basic polygon circle. Practically this task is solved as searching for inner integer point of triangle ABC where A and C are previous and following vertexes of moving vertex on the circle and point B is the central point of basic circle. In some cases such inner point doesn't exist and the central point is set as new vertex. Sometime such new vertex could fuse with one of other vertexes and the required vertex is not constructed. That's why the convexity of generated polygon has to be tested at the end of generating function and the result is set to output parameter `convex`.

Next function creates polygon figure in axes system `ax`. The coordinate dash lines are included to reach legibility of important polygon characteristics.

```
function ok = Create_polygon_figure(ax,polygon)
```

Following functions are employed in construction of linear inequations that define displayed polygon.

```
function line = create_line(A,B)
function equation = create_equation(line)
function inequation = create_inequation(point,line,belong)
```

The first of these three functions creates line from two points in general form i.e. it computes the coefficients  $a, b, c$  of line. These coefficients are attributes of the output object `line`. Second function creates equation of line as string. Last function creates inequation string of half-plane with input parameter `line` as a border line and point that belongs to half-plane (input parameter `belong = true`) or it doesn't belong (parameter `belong = false`). The combination of corresponding inequations or equations, and the correct and wrong answers are assembled as string.

The answers to the quiz question are generated as follows:

- When generating of correct answer string the method `create_inequation` parameter `belong=true` is applied for all lines of polygon. In the case of a non-convex polygon this answer is wrong.
- The first wrong answer is generated similarly as previous answer but the parameter `belong` is set to `false` randomly for one, two or any other number of polygon lines.
- Second wrong answer is created with application of `create_equation` method for all polygon lines. The equations system is a result of this generation.
- Third wrong answer consists of half-plane inequations. The half-plane are defined by lines  $x_1 = \min(V(i).x)$ ,  $x_1 = \max(V(i).x)$ ,  $x_2 = \min(V(i).y)$ ,  $x_2 = \max(V(i).y)$  and some inner point of polygon (center of basic polygon circle).
- Last wrong answer is "None of the above". In the case of non-convex polygon this answer is correct.

Examples of randomly generated quiz questions using algorithm described above can be seen on the following figures Fig. 1 and Fig. 2.

1. (1 point) Which of the following systems of simultaneous linear constraints defines the feasible region of the LP problem shown in the figure?

Check in the circle just one answer.

- ☐  $x_1 > 3; 2 \cdot x_1 - x_2 \geq 0; x_1 + 2 \cdot x_2 \geq 5; x_1 \leq 3$
- ☐  $x_1 \leq 3; x_1 \geq 1; x_2 \leq 4; x_2 \geq 1$
- ☐  $x_1 + 2 \cdot x_2 \geq 5; 2 \cdot x_1 - x_2 \geq 0; x_1 + 2 \cdot x_2 \geq 5; x_1 \leq 3$
- ☐  $x_1 = 3; 2 \cdot x_1 - x_2 = 0; x_1 + 2 \cdot x_2 = 5; x_1 = 3$
- ☐ None of the above

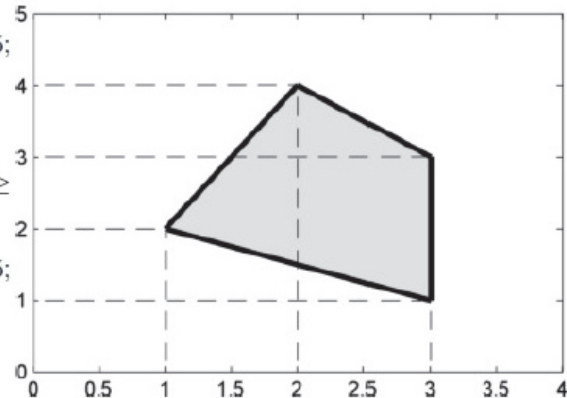


Figure 1: Example 1a) of randomly generated question concerning Feasible region

2. (1 point) Which of the following systems of simultaneous linear constraints defines the feasible region of the LP problem shown in the figure?

Check in the circle just one answer.

- ☐  $2 \cdot x_1 - x_2 = 5; x_1 - 2 \cdot x_2 = -6; x_1 + 2 \cdot x_2 = 6; x_1 + x_2 = 4; 2 \cdot x_1 - x_2 = 5$
- ☐  $x_1 + x_2 \geq 4; x_1 - 2 \cdot x_2 \geq -6; x_1 + 2 \cdot x_2 \geq 6; x_1 + x_2 \geq 4; 2 \cdot x_1 - x_2 \leq 5$
- ☐  $2 \cdot x_1 - x_2 > 5; x_1 - 2 \cdot x_2 < -6; x_1 + 2 \cdot x_2 < 6; x_1 + x_2 \geq 4; 2 \cdot x_1 - x_2 > 5$
- ☐  $x_1 \leq 4; x_1 \geq 0; x_2 \leq 4; x_2 \geq 1$
- ☐ None of the above

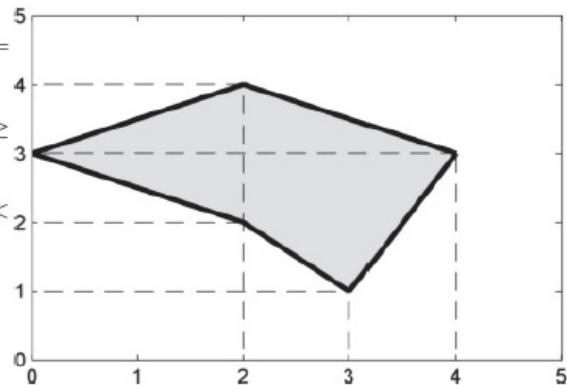


Figure 2: Example 1b) of randomly generated question concerning Feasible region

## Example 2 - Spanning tree

The second example presents a case of quiz question with generated images based on random input parameters as a part of the question assignment, and at the same time as a part of answers in multi-choice options. The aim of the task is the selection of a correct image showing the spanning tree corresponding to the graph illustrated on the image in question assignment.

Several problems must be solved when generating the graph and its spanning tree.

```
function Graph = Generate_graph(n)
```

This function generates randomly  $n$  vertexes on imagined circle. Then it generates randomly  $m$  edges, where  $m \in \langle 6; \text{floor}(3/2 \cdot n) \rangle$ . The vertexes are represented as array of points (two coordinates object) and edges are represented as set of pairs of vertex array indexes.

The following function displayed the graph in a nonvisible axes system and it numerates the vertexes.

```
function ok = Create_graph_figure(ax,Graph)
```

To display the correct answer the spanning tree has to be generated. Following method creates this sub-graph.

```
function SpanningTree = Create_spanning_tree(Graph)
```

Algorithm of this function selects edges consecutively from the edges set of main graph. With the help of `Path_exists` function it checks for every edge, whether the path between vertexes `vertex1` and `vertex2` (except of the edge itself) exists or not. If such path exists, the edge is taken from graph and algorithm continues with next edge until the number of edges is equal  $n-1$  or all the edges are analysed.

```
function yes = Path_exists(vertex1,vertex2,Edges)
```

Function `Path_exists` uses recursive principle with respect to following steps:

1. If edge (`vertex1`, `vertex2`) is an element of the set `Edges` then the path exists and function return result `yes = true`.
2. If such edge doesn't exist, we explore all edges containing the vertex `vertex1` as one vertex and any `vj` as the second vertex. We take out every such edge from the set `Edges`. The modified set of edges `EdgesTmp` is used for the following path searching between vertexes `vj` and `vertex2`. We search this path by recursive call of function `Path_exists(vj, vertex2, EdgesTmp)`. This way we explore all the edges outgoing from vertex `vertex1` in a cycle.

The method `Create_spanning_tree` is used for creation of image representing the correct answer. The same method serves to image creation of wrong answers:

- First wrong answer is created by the same process as spanning tree creation, but the cycle of edges withdrawing ends when the number of edges is equal to  $n$ .
- The second wrong solution is derived from constructed spanning tree. In this graph we find the vertex with only one edge. Then the vertex and the edge are taken out from graph.
- Third wrong answer is derived again from the spanning tree and a vertex with one edge. In this case the edge is taken out only and a new edge containing the selected vertex and any other vertex is added to the graph. The new edge mustn't belong to the set of edges of the original graph. That's why the resulting graph is not the sub-graph and consequently nor spanning tree of the original graph.
- The last wrong answer is "None of the above".

Of course, if we substitute the correct answer by some other wrong one than the last option is set as correct.

Examples of randomly generated quiz questions using algorithm described above in this sub-section can be seen on the following figures Fig. 3 and Fig. 4.

1. (1 point) Which of the following option shows a spanning tree of the graph depicted in the figure?

Check in the circle just one answer.

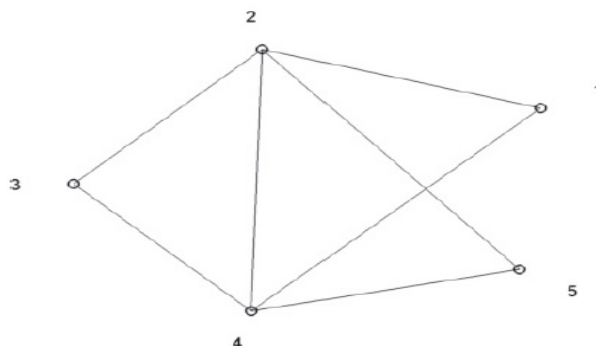
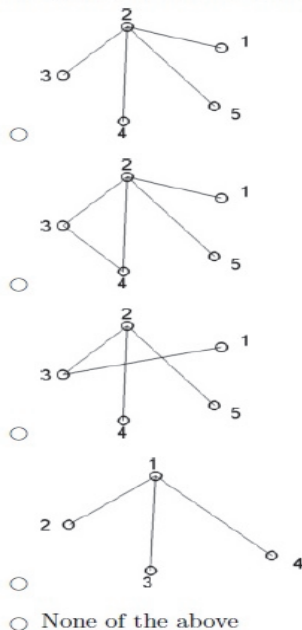


Figure 3: Example 2a) of randomly generated question concerning Spanning tree

1. (1 point) Which of the following option shows a spanning tree of the graph depicted in the figure?

Check in the circle just one answer.

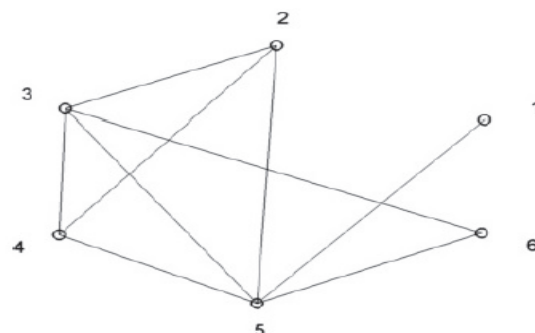
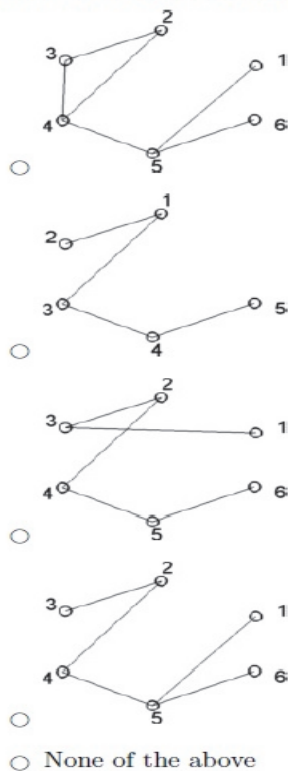


Figure 4: Example 2b) of randomly generated question concerning Spanning tree

## CONCLUSION

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In the paper we presented some ideas for automatic generation of quiz questions that include the automatically-generated variants of images. Two principal cases of questions with generated images based on random input parameters were discussed. The first case presents a state of question in which the generated image is a part of the question assignment. The second case presents a state in which the generated images represent the correct and incorrect answers in form of various modifications.

We identified several partial sub-problems to be solved when generating such questions containing randomly generated images. These sub-problems include the necessity to use sufficiently simple image, to omit the senseless or to the question inappropriate images when generating the input parameters randomly, to check the correctness of the resulting image in context of the text of the question, and to solve the problem of inventing the plausible wrong solutions to the multiple choice question. We suggested some possible ways of solving these problems by entering constraints limiting certain parameters of the image. Nevertheless, the selected method of solving has always to be chosen with regard to a specific task.

In the practical part of the article we presented two particular examples of generating the questions containing images. These examples include both the above principal cases, i.e. the generated image is a part of the basic text of the question, and the case in which the correct and incorrect variants of answers to the question are represented by different modifications of an image.

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# Importance of Information and Communication Technology for Academic Success from Students' Perspective

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## Abstract

*This paper presents selected findings from an ECAR Study 2014-inspired survey carried out at University of West Bohemia between December 2014 and March 2015. The purpose of the survey was to provide data for updating the curricula and teaching methodology for informatics at the Faculty of Applied Sciences and teacher training at the Faculty of Education. To students in both groups, information and communication technology (ICT) is not just a means of learning but also the subject of studies (informatics and informatics in education). The survey used an electronic questionnaire with selected questions from the ECAR Study 2014. Their wording was identical to the original to ensure that the results were comparable with the data gathered abroad. The questionnaires were completed by a total of 169 students. The survey focused on the ownership of ICT devices among students, particularly various mobile devices (laptop, tablet, e-reader or smartphone), and on the students' use of specific technologies for learning and in the classroom. This paper concentrates on students' attitudes towards in-class use of technologies, and on their assessment of the importance of various technologies for academic success. When compared to ECAR Study 2014 data, our respondents place less emphasis on in-class use of smartphones, tablets and online collaboration tools. Furthermore, they are more sceptical, on the whole, of positive impacts of in-class use of technology on learning results.*

## Keywords

*Mobile technology. University students. Higher education.*

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## INTRODUCTION

Information and communication technology has become an integral part of life for students who are generally inclined to use and have favourable attitudes towards it. However, it appears that technology has only a moderate influence on students' active participation in various courses or on their connection/relation to other students or faculty (Dahlstrom and Bichsel 2014). Recent years have seen an increase in the interest in exploring the use of information and communication technology (ICT) in higher education. Some surveys have emerged which focus on students' attitudes, and on particular kinds of in-class use of technologies (Zounek, 2010, Bureš, et al., 2014, Staudková, 2015, Poláček, 2015).

Staudková (2015) points out that the role of technologies in learning is characterized by functions which provide speed and efficiency, which is dictated by external pressure. A wider range of didactic functions is used when technologies are deployed in a creative manner and from a didactic perspective which aims to fulfil educational objectives. In higher education environment, one can encounter both approaches but the pragmatic one prevails.

Relevant surveys of students' attitudes and device ownership showed that a considerable majority of higher education students are convinced that the use of ICT in education leads to good learning results. However, the time students spend on the internet or on social networks is rarely filled with scholarly activities. Most often, technology help students with matters of organization. Using technology, students share information about deadlines, exchange study materials, and support each other in preparation for exams. (Rohlíková, et al., 2013)

At the end of 2014, the EDUCAUSE association, Center for Analysis and Research, published the results of a thorough survey of the use of information and communication technology in education, the ECAR Study 2014 (Dahlstrom and Bichsel, 2014). Respondents from 213 institutions of tertiary education across 45 U.S. states and 15 other countries across the world answered questions regarding the ownership of devices, the ways they use technology, and their attitudes towards in-class use of technology. Czech Republic was not part of the ECAR Study 2014. The total number of respondents who took part in the survey was 75,306. One of the key findings of the ECAR Study 2014 was that students do frequently use technology for academic purposes but this use lacks depth. When technologies are used in the classroom, this tends to be on the teacher's initiative. However, both teachers and students fear that the use of technology may be distracting (diverting their attention from the instruction). Students view on-line learning tools (learning management systems – LMS) as indispensable to their studies but rarely use them to full extent. There is a clear difference from the findings from previous surveys conducted by EDUCAUSE since 2004. Instead of playing a minor role and being used occasionally for learning, the technology today is omnipresent in students' lives (Dahlstrom and Bichsel, 2014).

The results of the ECAR Study 2014 made us wonder whether similar trends can be found in the Czech Republic, and inspired us to conduct this survey. The goal of our research was to gather information for updating teaching methods in subjects concerned with information and communication technology – and do so prior to the planned re-accreditation of study programmes – to obtain relevant data from teacher trainees (students at the Faculty of Education) and students of informatics (at the Faculty of Applied Sciences), and to compare our findings to the data for a normative sample of respondents in the ECAR Study 2014. We attempted to establish what devices students own (focusing predominantly on mobile technology), how they use information and communication technology and what attitudes they have towards technology.

## METHODS

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In order to gather data from the respondents, an electronic questionnaire was developed using Google Forms. Students from a representative sample of student

population at two faculties of University of West Bohemia were invited by e-mail to complete this questionnaire. A total of 813 students were approached. This included 608 students at the Faculty of Education of University of West Bohemia (teacher trainees for the lower secondary and secondary levels of education, including undergraduate students preparing for teacher training) and 205 students at the Faculty of Applied Sciences of University of West Bohemia (students of informatics). Between December 2014 and March 2015, a total of 169 students completed the questionnaire (including 78 teacher trainees and 91 students of informatics).

The first part of the questionnaire comprised 5 questions regarding the general information on the respondent (duration, field, and form of study, age and gender). The next part included 27 selected questions from the ECAR Study 2014. The questions were in English and had exactly the same wording as in the ECAR Study 2014 but their Czech translation was provided so that all students, including those less proficient in English, could understand. The questions selected from the original questionnaire of the Student Study 2014 (EDUCAUSE 2014) included predominantly those concerning mobile technology, students' attitude towards technologies, and the use of technologies in learning. Making the original questionnaire shorter was as a key aspect in our opinion because the original ECAR Study 2014 was rather extensive and had a relatively low response rate (no more than approximately 7 %). The total questionnaire response rate in our study was 20.8 %.

The first part of the technical questions required students to evaluate their experience, relation with and attitude towards information and communication technology from 17 different perspectives, using a scale of 0–100. The next part of the questionnaire comprised two questions about their ownership of particular devices. The last 8 questions mapped in-class use of various technologies by the faculty, technology use by students for acquiring information about the organization of study and for learning purposes, and the importance of the technology use for academic success.

Before evaluating the data, we verified our metrics which were used for assessing the information and communication technology inclination. The verification involved their psychometric properties in terms of internal consistency and factorial structure. The purpose was to ascertain the comparability of our data with the ECAR Study 2014. (Dahlstrom and Bichsel, 2014). After successful validation, we compared the ICT inclination between informatics students and teacher trainees, and related the results to the findings from the ECAR Study 2014. Using an appropriate regression model, we found a fundamental impact of gender on ICT inclination. We also discovered certain differences in the extent of use and in the appreciation of importance of some mobile technologies between informatics students and teacher trainees in our study, as well as between the respondents in our survey and those in the original ECAR Study 2014. These results have been published and discussed in great depth in *Aula*, a journal for higher education and science policy (Rohlíková, et al., 2015). In the present paper, we focus on some original results of the above-described survey which concerned students' ownership of devices and their appreciation of importance of in-class use of technologies.

## RESULTS

Some of the most interesting outcomes of our survey relate to device ownership, the students' evaluation of the importance of these devices to studies, and the significance of in-class use of technologies by students. Table 1 shows that there are no statistically significant differences between device ownership in the groups of teacher trainees and informatics students. The same holds for these groups' view of the importance of such devices for academic success. It is clear that device ownership in both groups involved in our study is roughly comparable with the normative sample from the ECAR study. (However, the figures for e-readers, tablets and smartphones are somewhat lower in our study.) The importance of tablets and smartphones for academic success reported by the ECAR Study 2014 is slightly higher than in our study, whereas that of laptops and e-readers is roughly comparable.

Table 1: Ownership and importance of individual devices for academic success.

	Group 1 – teacher trainees ( $n_1 = 78$ )	Group 2 – IT students ( $n_2 = 91$ )	P-value of the z-test for 2 population proportions	USA normative sample (ECAR study)
Laptop	93.6 <sup>a</sup> /79.5 <sup>b</sup>	94.5 <sup>a</sup> /81.3 <sup>b</sup>	0.803/0.764 <sup>c</sup>	90 <sup>a</sup> /83 <sup>b</sup>
Tablet or iPad	47.4/11.5	37.3/11.0	0,178/0.912	47/20
Smartphone	82.1/25.6	85.7/20.9	0,516/0.465	87/29
Dedicated e-reader	20.5/2.6	15.4/4.4	0.384/0.522	23/4
Desktop computer	62.8/41.0	67.0/34.1	0.569/0.352	N/A

<sup>a</sup> Percentages of respondents in the given group who owned the device

<sup>b</sup> Percentages of respondents in the given group who reported the device as very important or important for their academic success (regardless if they owned this device or not)

<sup>c</sup> P-values of the two-proportion z-test (groups of the teacher trainees and the IT students) for the ownership the technology and the importance of the device for academic success, respectively.

Table 2 reports technology use during courses in the past year and students' expectation that better use of a particular technology could improve the effectiveness of their learning. It appears that the use of learning management systems, e-portfolios, and recorded lectures were more common among teacher trainees by a statistically significant amount. By contrast, informatics students used online collaboration tools significantly more often than teacher trainees. In terms of the other technologies, no substantial differences were found between these groups. When compared to the ECAR Study 2014, our respondents used less frequently online collaboration tools, smartphones and non-keyboard or non-mouse interfaces. As to the potential for improving student effectiveness, lecture recording, laptops and online collaboration systems are rated by students as the most powerful technologies. Nevertheless, our respondents are more sceptical, on the whole, of improving their effectiveness by better use of technologies – unlike the ECAR study respondents. This applies equally to both teacher trainees and

informatics students (no statistically significant differences were found between these groups on this question, unlike in the extent of technology use). This is particularly notable with LMS, online collaboration tools and non-keyboard or non-mouse interfaces.

Table 2: Extent of technology use during courses in the past year and expectations that the better use of technology can increase student effectiveness.

In the past year, I used.../ I could be more effective if I were better in using of...	Group 1 – teacher trainees (n <sub>1</sub> = 78)	Group 2 – IT students (n <sub>2</sub> = 91)	P-value of the z-test for 2 population proportions	USA normative sample (ECAR study)
...the course or learning management system	83.3 <sup>a</sup> /28.2 <sup>b</sup>	31.9 <sup>a</sup> /17.6 <sup>b</sup>	<0.001/0.099 <sup>c</sup>	83 <sup>a</sup> /51 <sup>b</sup>
...online collaboration tools	42.3/35.9	64.8 <sup>a</sup> /36.3	0.003/0.960	74/51
...my laptop during class	59.0/41.0	65.9/39.6	0.352/0.849	67/47
...my tablet during class	32.1/25.6	26.4/17.6	0.418/0.200	29/23
...my smartphone during class	39.7/21.8	44.0/16.5	0.580/0.379	57/33
...social media as a learning tool	50.0/17.9	39.6/25.3	0.174/0.250	46/29
...e-books or e-textbooks	65.4/32.1	58.2/33.0	0.342/0.897	56/42
...simulations or educational games	38.5/26.9	31.9/29.7	0.368/0.697	38/38
...recorded lectures or "lecture capture"	41.0/43.6	26.4/36.3	0.044/0.332	35/48
...nonkeyboard or nonmouse interfaces	12.1/9.0	9.0/8.8	0.516/0.979	30/17
...e-portfolios	47.4/21.8	27.5/14.3	0.012/0.285	23/24
...3D printers	4.4/17.9	9.0/13.2	0.246/0.390	8/22

<sup>a</sup> Percentages of respondents in the given group who reported the use of the technology in at least one course during the past year.

<sup>b</sup> Percentages of respondents in the given group who strongly agreed or agreed with the statement that they could be more effective if they were better at using the technology.

<sup>c</sup> P-values of the two-proportion z-test (groups of the teacher trainees and the IT students) for the use of the technology and the expectation of the improved effectiveness due to the technology, respectively.

Note. Values in bold represent cases in which the hypothesis of the same proportion in both groups studied was rejected for a significance level of 0.05.

Table 3 reports the importance that students attach to the use of mobile devices for various study-related activities. Surprisingly, it was found that teacher trainees – considerably more than informatics students – value the opportunities to access library resources, register for courses, use LMS, look up information and communicate with other students about school-related matters. This is despite the fact that mobile device ownership levels are comparable in both groups. As to the use of mobile devices for recording lectures and taking photographs, for proving student identity, gaining access to LMS, or taking part in interactive class activities, our respondents found these less important than the respondents in the ECAR Study 2014 (in the case of LMS, this may be due to these systems being less widespread in our environment). Less importance was also placed on accessing information about various events, student activities and associations. The importance attached to communication with others, finding information and checking marks was comparable in both studies. By contrast, Czech students rated the opportunity to register for courses via mobile devices as more important than the ECAR respondents.

Table 3: Importance of using a handheld mobile device for various student related activities.

How important is it that you are able to do the following activities from a handheld mobile device (e.g. smartphone or tablet)?	Group 1 – teacher trainees (n <sub>1</sub> = 78)	Group 2 – IT students (n <sub>2</sub> = 91)	P-value of the z-test for 2 population proportions	USA normative sample (ECAR study)
Record instructor's lecture or in-class activities	17.9 <sup>a</sup>	23.1 <sup>a</sup>	0.637	52 <sup>a</sup>
Use the mobile device as a digital passport for access or identification	30.8	29.7	0.412	57
Participate in interactive class activities	30.8	35.2	0.542	63
Register for courses	82.1	65.9	<b>0.018</b>	64
Access library resources	64.1	37.4	<b>&lt;0.001</b>	64
Capture static images of in-class activities or resources	46.2	33.0	0.080	66
Read e-texts	46.2	46.2	1.000	68
Access information about events, student activities, and clubs/organizations	60.3	57.1	0.682	74
Use the course or learning management system	65.4	45.1	<b>0.008</b>	77
Look up information while in class	80.8	67.0	<b>0.044</b>	79

Check grades	82.1	70.3	0.076	83
Communicate with other students about class-related matters outside classes	93.6	69.2	<b>&lt;0.001</b>	85

<sup>a</sup> Percentages of respondents in the given group who reported the possibility to use a mobile device for the activity as at least of moderate importance.

Note. Values in bold represent cases in which the hypothesis of the same proportion in both groups studied was rejected for a significance level of 0.05.

## DISCUSSION

Respondents in the ECAR Study 2014 consider tablets and smartphones more important for academic success than our respondents. Our respondents find it less important to have an opportunity to record lectures and take photographs during lectures using mobile devices. The same applies to using mobile devices for identification, for access to learning management systems and for participation in interactive activities in the class. Less importance is also placed by our respondents on accessing information about various events, student activities and associations via mobile devices. This confirms the findings by Švaříček and Zounek (2008) that advantages and new learning opportunities do not come automatically with the use of technologies, and that teachers and students often fail to realize the educational potential of particular information and communication technology. A relatively low level of ownership of mobile devices among our respondents, namely tablets and e-readers but also smartphones, in the comparison with the respondents in ECAR Study certainly plays a significant role here. If students do not own a particular device, they naturally feel less need for their institution to deal with the use of that kind of technology, and often fail to imagine areas in which that might be appropriate or necessary.

ECAR Study 2014 respondents and our respondents share an approximately equal level of interest in communication with others, accessing information and checking marks using mobile devices. Our respondents rate the opportunity to register for courses via mobile devices as more important than the ECAR respondents. These findings are in line with previous surveys which highlighted the main purpose for which students use technologies: organization of their studies and communication with others (Rohlíková, et al., 2013). Hence, e-learning in the Czech environment does not always entail changes in teachers' methods of working and in students' learning styles, although students do gain wider opportunities for learning. This stands in contrast to claims made in some surveys conducted abroad (Wishart and Blease, 1999).

The comparison between samples from the Faculty of Education and the Faculty of Applied Sciences does not reveal any substantial differences. Device ownership among students at both faculties is at similar levels. However, teacher trainees show greater appreciation of the opportunity to access library resources, register for courses, use LMS, look up information and communicate with other students about school. We found teacher trainees to possess more experience with LMS in their studies. This finding may be



attributed to the higher proportion of women among teacher trainees (cf. gender-related differences in attitudes towards and the use of ICT – Palaigeorgiou et al., 2005, Demirli, 2013) and to the more frequent use of LMS at the Faculty of Education. The latter is a result of earlier projects for developing e-learning study materials using Moodle LMS. By contrast, Moodle-based materials for students at the Faculty of Applied Sciences are much less common.

The survey revealed that students have relatively little experience in using on-line tools and mobile devices in the classroom. This might be due to previous negative experience arising from inadequate deployment of technology or from poor-quality e-learning materials encountered by the students. Zounek a Sudický (2012) reported that some people are faced with the barrier of their own unfounded aversion to ICT, and that there are some young people who cannot handle technologies well enough and without their studies being hindered. Another cause may lie in the fact that the current in-class use of ICT is often limited, linear and rigid, which is rather far from the ideal of a creative, productive and powerful tool, as seen by advocates of ICT in education (Selwyn, 2007).

We are well aware that the outcomes of our survey are unfit for generalizing to the entire Czech Republic or for deriving international comparisons without keeping in mind its constraints. The ECAR Study 2014 was carried out mostly in the U.S., Canada and other countries, in which the approach to education and the systems of tertiary education differ markedly from the Czech ones. We believe that our survey can become a source of inspiration for local changes in the use of didactic tools (at University of West Bohemia), and provide a relatively broad basis for further surveys that may include larger numbers of respondents while exploring specific issues in greater depth.

The results of the study call for more intensive popularization of the use of information and communication technology in education and for regular dissemination of examples of best practice. There is a need for seminars for students where methods and strategies for improving academic success by means of information and communication technology will be introduced, as well as for courses for faculty, in which the potential of technologies for in-class use will be discussed and, last but not least, for greater emphasis on research into this field.

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## ACKNOWLEDGEMENT

We gratefully appreciate the consent of the ECAR STUDY 2014 authors, Eden Dahlstrom and Jacqueline Bichsel, with our use of selected questions from the ECAR STUDY 2014 in our survey.

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# Problems, Experiences, and Perspectives of Implementing Social Media in Online Tutoring

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## Abstract

*With extensive implementation of online tutoring at the level of the university education and a boost of social media use for learning purposes, the question arises if social media tools are beneficial for the quality of online tutoring or, it is a distraction which overburdens tutors and students, and whose functions can be successfully realised within learning management systems (LMS). Due to the urgency of the issue, the study is aimed to analyse current problems, experiences and perspectives of implementing social media in the format of online tutoring with the reference to the formal education. The research is based on the analysis of the recent case studies, projects and theories concerning online tutoring and social media. Based on the findings the paper lays out specifics of online tutoring methodology, defines clusters of ICT tools required to realise different purposes of online tutoring. Together with that, the paper highlights features and activities of online tutoring which can be realised with the help of social media tools. Based on the analysis of the recent research, main features of social media which are disputable in the context of online tutoring have been distinguished. They are: 1) the role of social media in enhancing learning outcomes; 2) capabilities of social media to facilitate collaborating learning; 3) the role of social media in facilitating communication, personal and group development; 4) establishing learning communities with social media; 5) students' willingness to use social media for learning purposes; 6) the ability of social media to develop critical thinking and creativity; 7) manageability of social media versus LMS interface. In the context of the distinguished features the benefits and perils of social media from the perspectives of different experiences are discussed. In the conclusion the paper presents recommendations on social media implementation in online tutoring regarding the problems discovered.*

## Keywords

Online tutoring. Social Media. Learning. Students. ICT Tools. Collaborative Learning. Learning Community.

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## INTRODUCTION

Due to the extensive development of online tutoring as an alternative form of education it is under concern how to enhance the quality of learning mediated by ICT tools regarding advances in online pedagogy and ICT designed for educational purposes.

Together with that the problem of social media in online tutoring is widely discussed, and it turned to become similar in its character to the debates over the formal and informal learning, i.e. whether social media is a kind of distraction and more an entertainment than learning, the tools which violate norms of educational ethics or, it is the solution to enhance the interactivity and personalisation of online tutoring, moreover when we speak about massive open online courses (MOOCs).

Considering the problems under concern this study is aimed to analyse the status of social media in the context of methodology of online tutoring, its potential for enhancing the quality of online tutoring in terms of communication, interactivity, personalisation, and creativity in learning.

As it is known social media and social networking are in most cases defined as “Web 2.0” tools and platforms that enable “user-generated content” through writing and uploading to a webpage (Using social media for teaching and learning – Staff Guide, 2014). Examples of social media technologies that can be used for learning and teaching include: discussion forums, blogs, wikis, and 3D virtual worlds (Sekret, 2012). External social media sites include Facebook, YouTube, Wikipedia, Flickr, Twitter, LinkedIn, Second Life, etc.

In the framework of the current research the social media are defined as technologies that facilitate social interaction (Sekret, 2013), make possible collaboration, and enable deliberation across stakeholders. These technologies include blogs, wikis, media (audio, photo, video, text) sharing tools, networking platforms (including Facebook), and virtual worlds (Bryer & Zavattaro, 2011; Chen & Bryer, 2012; Sekret, 2012, 2014).

For the last decade the role and place of social media in formal education have been widely discussed in the literature. Together with the studies that advocate implementing social media tools in the framework of the higher education (Balakrishnan, 2013; Blaschke, 2014; Sekret 2014; Salmon *et al.*, 2015), there is a number of research reporting on a distractive pattern of social media in learning (Aghili *et al.* 2014; Davies *et al.* 2010; Salmon *et al.*, 2015).

The current research is an attempt to shed the light upon the problem under discussion. The research is based on the analysis of the recent case studies, projects and theories concerning online tutoring and social media.

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## METHODS

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To reach the aim of the study the following methods were applied:

- analysis of the recent publications on the online pedagogy advancements, projects and case studies concerning online tutoring in order to specify its methodology;
- observations, case study analysis, interviewing experts in online pedagogy and ICT tools, with the purpose to define specific aims of online tutoring and ICT tools implemented to realise them, with a further specification of ICT tools clusters applied for different purposes of online tutoring;
- analysis of recent projects and case studies concerning social media in online tutoring in order to highlight the role which can be fulfilled by the social media tools in online tutoring, to identify problems in implementing social media in

the context of online tutoring and specifics of communication and interaction via social media for the purposes of online tutoring.

## **RESULTS**

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Following the logic of the study and aims which were put forward to define problems, experiences and perspectives of social media in online tutoring the results of the research are grouped respectively: 1) methodology of online tutoring; 2) ICT tools implemented in online tutoring; 3) the role of social media in online tutoring and problems of its implementation.

### **Methodology of Online Tutoring**

Nowadays a big amount of research and studies focus on the problems of online learning. The scope of the questions under concern range from the pure theoretical, defining pedagogy and methodology of online learning, to those, describing online practices and case studies.

Due to a variety of pedagogies and approaches applied, the concept of online learning turns to be a broad one including different forms of ICT-mediated. While most researchers define the concept as access to learning experiences via the use of some technology (Carliner, 2004; Gümüş & Okur, 2010; Regan et al., 2012) and as wholly online learning (Oblinger & Oblinger, 2005), others consider it as a new form of distance learning (Benson, 2002). Khan (2005, p.3) defined online learning as “an innovative approach for delivering a well-designed, learner-centered, interactive, and facilitated learning environment to anyone, any place, any time by utilizing the attributes and resources of various digital technologies along with other forms of learning materials suited for open, flexible, and distributed learning environments”.

In the literature, online tutoring is often referred to as a process of teaching in an online, web based or virtual environment in which teachers and learners are separated by time and place (Denad, 2003; Flowers, 2007).

According to the definition brought by Cornelius & Higgison (2001), tutoring or moderating include “those aspects of a teacher’s work which involve managing and ‘animating’ interactions with and among learners, especially with respect to their participation in networked learning activities”.

The results of the literature analysis and recent case studies allow outlining specifics of online tutoring as following:

- Methodology of online tutoring is based on the principles of constructivist and social-constructivist pedagogies.
- Main components of online tutoring include: a) adopting a specific pedagogy or an educational method, which conditions ways and strategies of the learning content delivery and providing social support for the learning group; b) organisation and coordination of supplying services of online tutoring; c) a coherent system of ICT tools with the manageable interface; d) technical support for the online tutoring system to function smoothly and to be adjusted to the learning purposes.

- Forms of providing online tutoring depend on the learning needs, content of learning, the scope of the topics under discussion, number and character of its participants. Therefore, there can be distinguished: a) many-to-one online tutoring; b) peer online tutoring; c) one-to-one tutoring; d) tutoring provided by automated tutoring systems; e) online tutoring as e-moderation for facilitating the mainstream learning; etc.
- Online tutoring can be conducted in synchronous and asynchronous modes, or combining both modes of communication and interaction.
- Alongside with delivering the learning content, effective online tutoring presupposes performing scaffolding, weaving, facilitating discussions, and providing feedback. Due to the specifics of the ICT-mediated learning environment and absence of possibilities for face-to-face contacts, the mentioned teaching processes, which are extremely essential for learning and being realised naturally in a traditional classroom, remain to be a problematic area for the online tutoring class. They require to be transformed and adapted to the conditions of online tutoring via appropriate ICT tools and communicative strategies.
- Online tutoring is conducted in most cases via virtual learning environments (VLE) or LMS involving also other ICT tools for developing learning content (presentations, video, podcasts, etc) and facilitating communication in the learning group.

Therefore, effective online tutoring should be based on the following principles: 1) Independent Learning and Students' Autonomy; 2) Collective Knowledge Construction; 3) Transformative Learning; 4) Establishing Communities of Practice; 5) Dialogical Learning; 6) Self-reflection.

### **ICT tools implemented for the Purposes of Online Tutoring**

Nowadays there is a big diversity of ICT tools which are applied for the purposes of online tutoring. They can be grouped due to their specific functions.

1. Virtual Learning Environments (VLE) and Learning Management Systems (LMS) as main platforms of online tutoring.
2. Social media tools for mediating instant communication, establishing communities of practice, socialisation in the learning group.
3. ICT tools for video/audio podcasting and online conferencing interface.
4. Intelligent tutoring systems.

Examples of ICT tools which are most popular among online tutors and learners are represented in Table 1.

Table 1: ICT Tools for the Purposes of Online Tutoring.

Nº	Purposes in online tutoring	ICT tool name	Comments
1	Providing virtual learning environment	<b>VLE (virtual learning environment):</b> <b>Open source VLEs</b> Moodle, eFront, OLAT, Sakai, ILIAS, ATutor, Fedena, openelms, Claroline, Dokeos EasyClass  <b>Commercial VLEs</b> Blackboard, Lotus Workplace, COSE, WebCT	Main platforms for online tutoring; Equipped with all main functions required for managing the learning process; Universities tend to develop their own virtual learning platforms; In the university the instructors can be entitled to use LMS of the institution, and also they may be free to use other LMS in addition to the main one depending on the local policy; Possible weaknesses of LMS: lack of options for instant communication, too complicated for the users, unfriendly design
2	Establishing communities of practice  Realising dialogical learning  Opportunities for individualised scaffolding	<b>Social media tools:</b> Facebook Twitter Google + Blogger Periscope Instagram VK Second Life	The purpose is to provide possibilities for sharing tips and practices, questioning, discussing, supporting, developing a sense of community; Second Life and other Massive online games are used to establish communities for interaction, modelling situations relevant to the content of the learning, discussing possible strategies and solutions; Weaknesses: restrictions on ethical issues, local policies, individual attitudes
3	Peer tutoring (audio/video connection)  Synchronous online tutoring  Opportunities for individualised scaffolding	<b>Online conferencing interface:</b>  Adobe Reader Connect Skype Viber WhatsApp Hangouts	There are commercial and free tools, free tools are more popular among users; Usage of the tool can be restricted by the local policies or technical limitations, and popularity among users in the area; Conferencing options vary in a number of participants allowed per one synchronous session Tools mentioned are popular for instant communication, announcing, exchanging information



4	Asynchronous online tutoring	<p><b>Mailing, blogging, audio/video podcasting:</b></p> <p>E-mail Blogger iTunes YouTube</p> <p><b>Tools for creating audio/video podcasts:</b></p> <p>iMovie PowerPoint Camtasia Videvo <a href="http://www.videvo.net">http://www.videvo.net</a></p> <p><b>Augmented reality apps:</b></p> <p>Aurasma App <a href="https://studio.aurasma.com">https://studio.aurasma.com</a> Daqri <a href="http://daqri.com">http://daqri.com</a> etc.</p>	<p>The purpose of arranging the learning materials for asynchronous tutoring is most cases realised with the ICT tool, which is most familiar to the instructor; among them available <b>media players</b>, media libraries, online radio broadcasters, and mobile device management applications. used to play, download, and organise digital <b>audio</b> and video;</p> <p>Familiarity with the ICT tool and experience of dealing with it are the most crucial factors for the instructor to choose and apply the tool. Therefore, in spite of a huge diversity of applications for video and audio podcasting, their penetration into the classroom remains to be better</p>
5	<p>Knowledge constructing / group-based learning</p> <p>Mural writing</p>	<p>Massively multiplayer online role-playing games (MMORPGs)</p> <p>Google disk</p>	<p>- MMORPGs blend the genres of role-playing video games and massively multiplayer online games, potentially in the form of web browser-based games, in which a very large number of players interact with one another within a world;</p> <p>- ICT tools for mural waiting allow learners to work at the same piece of writing being distant from each other in time and space</p>
6	<p>Reflection</p> <p>Self-reflection</p>	<p><b>Blogging:</b></p> <p>Blogger Google + Facebook Google disk</p>	<p>ICT tools for blogging help to collect info on the students' evaluation of the classes, their reflections on learning experience; it is possible to trace their progress during all the course;</p> <p>Analysis of the wirings in blogs is a good resource for the tutor for self-reflection and self-evaluation</p>

7	Machine tutoring (automated tutoring)	<b>Intelligent tutoring systems (ITS):</b>  AutoTutor <a href="http://ace.autotutor.org/IISAutotutor/index.html">http://ace.autotutor.org/IISAutotutor/index.html</a>  CognitiveTutorAuthoring Tools <a href="http://ctat.pact.cs.cmu.edu">http://ctat.pact.cs.cmu.edu</a> etc.	- Computer systems that aim to provide immediate and customized instruction or feedback to learners, usually without intervention from a human teacher
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### The Role of Social Media in Online Tutoring and Problems of its Implementation: Benefits and Perils.

Due to the fact that a great number of research and case studies have been conducted in the area, and their results and conclusions may seem misleading because of the controversy of their statements, it was decided to highlight exact pros and cons of social media tools and organise them in the table to show the tendencies and come up with the recommendations how to manage social media tools in the context of online tutoring and therefore define perspectives of social media tools application in learning.

Based on the results of the recent studies and researchers' conclusions, a set of features of social media concerning its use in the context of online tutoring has been defined. The main of them are: 1) the role of social media in enhancing learning outcomes; 2) capabilities of social media to facilitate collaborating learning; 3) the role of social media in facilitating communication, personal and group development; 4) establishing learning communities with social media; 5) students' willingness to use social media for learning purposes; 6) the ability of social media to develop critical thinking and creativity; 7) manageability of social media versus LMS interface (Table 2).

Table 2: Featuring Social Media for the Purposes of Online Tutoring: Benefits and Perils. Results of the Literature Analysis.

Purposes of Online Tutoring	Benefits	Perils
1. <i>The role of social media in enhancing learning outcomes</i>	Enhancing learning outcomes and academic achievement (Junco, <i>et al</i> 2010; Özmen & Atici 2014)	Use of social media such as Facebook is time wasting or a form of procrastination (Davies <i>et al.</i> 2010)
	Contributing to knowledge construction (DeWitt <i>et al.</i> 2014; Kassens-Noor 2012)	
	Social media is useful for posting and gathering information, Facebook improves learning outcomes by facilitating discussion with peers and moderators (Davies <i>et al.</i> 2010).	
	Facebook is an easy aid to increase learning and encourage discussions	

Purposes of Online Tutoring	Benefits	Perils
	with peers as it facilitated the sharing of videos and images, and allows participants to directly see others' work (Salmon, G.et. al., 2015)	
2. Capabilities of social media to facilitate collaborating learning	Facebook and Twitter as social media platforms contribute to collaborative learning experiences (Balakrishnan 2013; Blaschke 2014, Sekret 2013).	Reducing student collaboration because students work separately on different parts of a project, and this minimises opportunities for collaborative learning (Hrastinski & Aghaee 2012).
3. The role of social media in facilitating communication, personal and group development	Assisting students to share administrative information with peers, such as meeting times and locations, and assessment requirements (Selwyn 2009, Sekret 2014)	Using social media in learning may lead to misunderstandings, less knowledge sharing, and less creative thinking (Hrastinski & Aghaee 2012)
	Promoting peer feedback (Davies <i>et al.</i> 2010).	Quality and accuracy of the information shared in collaborative social media spaces varies greatly (Laird 2014)
	Strengthening the social relationships among students, heightening students' self-esteem, and boosting their learning performance (Llorens & Capdeferro 2011).	Students may feel that using social media in education distorts the boundaries between their online social and educational worlds, between social and informal and formal spaces, and between public and private spaces (Aghili <i>et al.</i> 2014; Tess 2013)
	Students may be more willing to voice their opinions or disagreement with peers in an online discussion rather than in a face-to-face setting (Kim 2008, Sekret 2014)	Participants may feel overwhelmed and as just one 'faceless student' out of many, it can cause a sense of loss of identity and individuality (Levinson 2013; Knox 2014).
	Online social interaction allows shy students to contribute and be 'heard' by the group (Davies <i>et al.</i> 2010)	Potential merging of professional and social identities (Aghili <i>et al.</i> 2014; Veletsianos & Navarrete 2012)
4. Establishing learning communities with social media	Facilitating the development of online communities, allowing for collaborative and participatory engagement by placing emphasis on collective knowledge and social interaction (Wodzicki <i>et al.</i> 2012)	
	Benefits of networking with people from different backgrounds, locations and professional affiliations when using social media platforms to connect and further their learning outcomes in the online course (Sekret, 2013, 2014; Salmon <i>et. al.</i> , 2015).	

Purposes of Online Tutoring	Benefits	Perils
5. Students' willingness to use social media for learning purposes	Social media platforms tend to be more popular with students for peer-to-peer interactions (Davies <i>et al.</i> 2010; Veletsianos & Navarrete 2012, Sekret 2012)	Students are not keen to use Facebook for formal discussions relating to teaching and learning, or to liaise with instructors (Madge <i>et al.</i> , 2009)  Some students are negative towards social media in general, seeing it as a waste of time, both inside and outside of the online course (Salmon <i>et. al.</i> , 2015).
6. The ability of social media to develop critical thinking, and creativity	Peer learning communities (off and online) have been identified as a way to foster the development of higher order thinking skills and increase student and academic engagement, interaction, retention, and satisfaction (Sekret 2013, 2014; Yuan & Kim 2014)	No adequate evidence that social networks provide an arena for all students to develop critical and independent thinking skills (Henderson <i>et al.</i> , 2015)
7. Manageability of social media versus LMS interface	Facebook serves as a spark for a discussion, which could then be built upon within the more structured MOOC environment (Salmon <i>et. al.</i> , 2015)  Learners find social media easier to use, or more 'advanced' than the institutionally provided LMS (Salmon <i>et. al.</i> , 2015).	Students being comfortable with social media, however, avoid unfamiliar platforms whether it is LMS or social media tool (Salmon <i>et. al.</i> , 2015, Sekret, 2014)  All information should be in one place, such as the official LMS, and information spread over several social media sites can make the students feel lost (Knox 2014; Henderson <i>et al.</i> , 2015)  Difficulties about reaching consensus which platforms to use for their work (Salmon, G.et. al., 2015).

## DISCUSSION

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Despite the current controversial disputes dearth of on the effects of social media tools on the academic and social outcomes of university students, long-standing theories in the field of higher education provide a foundation for viewing social media as having potential to enhance student success (Deil-Amen, D., Rios-Aguilar, & Canche, G., 2012). Many theoretical frameworks state that implementing social media contributes to engagement and involvement, and social and academic integration, a sense of belonging to the community. These features are regarded as benefits which lead to higher learning achievements, retention of knowledge, and higher motivation to learning as a whole, especially in case of being distant from real learning community as in a case of online tutoring. Together with that, it is stated that some learners avoid using social media because of 1) their belief that social media might be a waste of time; 2) the perception of

social media platforms as confusing or intimidating; and 3) concerns about blurring social and professional identities (Salmon, G., Ross, B., Pechenkina, E., Chase, A.-M., 2015).

## **CONCLUSIONS**

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Following the results of the research and related discussions it can be stated as below:

1. When designing a course conducted in the mode of online tutoring it is essential to consider the main learning platform and its limitations as for communication, collaboration and interactivity.
2. Due to the results of the study LMS in many cases is not efficient for providing collaborative virtual environment, therefore social media is widely introduced to fill the gap.
3. At the preparatory stage it is recommended to consider students' preferences and attitudes to social media in order to choose a platform shared by all the learners, and to identify clearly aims of implementing social media tool, activities, which are going to be conducted within LMS or social media platform.
4. The outline of the course, its content and learning activities should be designed in the account of the learners' educational, demographic and cultural background. With this concern it is advisable to understand mainstreams of using social media among Internet users in a certain place and culture.
5. If the decision is positive about implementing social media in the framework of the online course, the platform should be selected regarding learners' preferences and, the number of social media channels of communication should be limited in order not to confuse the students, and not to make them feel lost in the stream of information and discourses.
6. To facilitate the access to the social media platform and not to overburden the learners with the issues of signing or logging in/out, it is advisable to incorporate the social media platform into the official LMS of the course.
7. In order to avoid frustration and intimidation for the students in joining the social media platform it is recommended to provide a brief pre-course instruction as for the strategies of behaviour in social media environment, and tips on keeping the learning community and environment apart from their personal space. The learners can be advised to settle their learning/professional profiles in the social media platform in order to preserve their privacy.
8. Considering the remaining controversy in different social and cultural communities as for the role and value of social media it is advised to implement social media tool as a complimentary to the main platform of the course. At the same time, clear explanation of the purposes of implementing social media tool in learning, distinct identification of activities which are going to be conducted via social media platform and benefits for the learning outcomes, will increase the learners' engagement and lower their frustration to communicate in the social media environment.

## ACKNOWLEDGEMENT

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The research leading to these results has received, within the framework of the IRNet project, funding from the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Programme FP7/2007-2013/under REA grant agreement No. PIRSES-GA-2013-612536.

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# The Inclusion of Gamification Elements in the Educational Process

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## **Abstract**

*Recently the concept of gamification started to gain attention. It has crossed its common ground and found its way into the sphere of education from marketing and business. The increasing number of scientific papers suggests that gamification might be more than just a modern buzzword. Some researches argue about its position as a new learning theory. It can be compared with others and enhance the current perspective of learning. However, the terminology and theory has not been yet fully established. As the research in the field progresses, some common definitions appear. But the basic two categories are already frequently distinguished: The gamification design principles and game design mechanics. The design principles are means for increasing motivation to learn, while game mechanics are the tools through principles are implemented. Interesting is the fact that some of the game mechanics help to achieve more than a single game principle, whereas others are strictly for one purpose. To demonstrate the real use of the gamification, the paper will analyze a learning environment heavily drawing on the concept of gamification and utilizing it to motivational ends, the internet website Duolingo was chosen for an analysis. The gamification design and game mechanics are elaborated on the examples from the application. The conclusion offers the learning mechanics that draw on the concept of gamification to aid students in their learning process, based on the students' own intuitive use of gamification in learning applications.*

## **Keywords**

*Analysis. Application. Education. Gamification. Game principles. Game mechanics. Motivation.*

## **INTRODUCTION**

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In the 21<sup>st</sup> century traditional education faces new challenges. The so called "generation Z" has entered the education process. Its members are able to use technology, social media and internet with ease. On the other hand, they face difficulties staying focused and keeping attention (Bíró, 2014). In the search how to address this issue a lot has been written. One of the possibilities is the gamification which might be considered new in the education field but definitely not new as a theory itself.

According to studies a plenty of research has been recently published on the topic of gamification. However, until 2008 it was mainly used by other branches, especially in business and marketing. Marketers were studying how to attract the customers to spent

more. It was found out that motivated customers return more frequently and gamification approach has helped to achieve this goal (Dicheva, Dichev, Agre and Angelova, 2015). Since 2008 it can be seen increased number of scientific papers dealing with gamification in education. The topic has become widely popular and studied recently.

This paper tries to capture the information needed to understand the gamification presented in current state of research, mainly based on the works of Karl Kapp (2012) and Gábor István Bíró (2013, 2014). Those are the studies frequently quoted by the other researchers in the field of education. The next aim of the paper is to reveal problematic areas such as unestablished terminology and differences in researchers' approach to the gamification theory. In the last part a gamified application example is chosen as a form of demonstration and analyzed based on from the theoretical perspective.

The reader should gain awareness of the topic of gamification after reading the paper. Based on the knowledge and analysis he should be able to recognize gamified application or environment from the non-gamified one. The reader will see the implementation of the gamification mechanics and principles including their positive and negative impact on motivation driven by the way of implementation.

## LEARNING THEORIES AND GAMIFICATION

Some researches asked themselves a question: if gamification can successfully work in the other studied fields how to apply it in the field of education. One of the approaches presented by Bíró (2014) puts forth the gamification as a theory compared side by side with Behaviorist, Cognitivist, Constructivist and Connectivist learning theories (see Table 7). It is argued that gamification works with intrinsic motivation (Ollson, Mozelius and Collin, 2015). Based on the discoveries of Karl Kapp (2012) individual components can be fully compared with other theories and gamification can be seen as a new perspective.

Table 7: The Comparison of Learning Theories (Bíró, 2014)

Components of learning	Behaviorist learning theory	Cognitivist learning theory	Constructivist learning theory	Connectivist learning theory	Gamification
<b>The learner</b>	instinct-driven individual	conscious individual	conscious individual	conscious individual	conscious individual
<b>Motivation</b>	extrinsic	intrinsic	intrinsic	extrinsic	intrinsic
<b>Knowledge</b>	external	internal	internal	external	internal /external
<b>The learning process</b>	environment-driven	ad hoc personal processing	systematic personal processing	ad hoc network processing	systematic personal processing
<b>The teaching focuses on</b>	the environment and the behavior of learners	the cognitive process of learners	the cognitive process of learners with a special view to prior knowledge	the dynamics of networks with a special view to knowledge-allocation	the environment and the cognitive process of learners
<b>Engagement</b>	individual	individual	individual	network-based	group-based
<b>The learning</b>	teacher	teacher	teacher	learner	teacher

<b>path is guided by the</b>				(discover different paths), and the teacher (choose one path)	(establish different paths), and the learner (choose one path)
<b>The attitude of teacher</b>	active	active	reactive	reactive	proactive
<b>The attitude of learner</b>	reactive	reactive	active	proactive	proactive
<b>Feedback</b>	individual	individual	individual	network-based	group-based

The unclear part of gamification is its terminology and definition. There is an agreement that the terms “game” and “gamification” must be distinguished from each other (Urh, Vukovic and Jereb, 2015). Gamification is often interpreted as “using game-based mechanics, aesthetics and game thinking to engage people, increase engagement, promote learning and solve problems” (Kapp, 2012). Thus the gamified learning environment uses some of the game aspects but it does not use the game itself as a tool, which can be referred to as Game based learning. The use of games in education is common and supported by psychologist Peter Gray (2015).

A mapping study of gamification in education discovered most frequently used terms and categories (Dicheva, Dichev, Agre and Angelova, 2015). The game elements have been divided into “Gamification design principles” and “Game mechanics.” Some authors use different terms (Bíró, 2013) but brackets are usually the same like “Game design methods and processes.” Gamification design principles are aspects which define features of the environment. On the other hand, Game mechanics are tools which help realize those design principles (Ollson, Mozeliuss and Collin, 2015).

The underneath are the principles ordered by the highest occurrence (Dicheva, Dichev, Agre and Angelova, 2015):

- Visible Status
- Social Engagement
- Freedom of Choice
- Rapid Feedback
- Freedom to Fail
- Goals and Challenges
- Storyline

Some minor principles which are still used includes: Unlocking Content, Personalization, Onboarding and Time Restriction.

The most occurring game mechanics are:

- Badges
- Leaderboard
- Points
- Levels

The achievement of the aforementioned rewards is displayed by use of Virtual Goods and Avatars, however, the first four mechanics are the most present in gamified learning environments (Dicheva, Dichev, Agre and Angelova, 2015).

Meanwhile game mechanics can be usually self-explanatory (the badges are frequently implemented as a badges and can be collected), the gamification design principles can be sometimes vague. Even the sources from Kapp (2012) describe slightly different view on some design principles.

To give a better idea, the second part of this paper focuses on the analysis of the real learning environment, which uses all the aspects described previously. Each gamification design principle and game mechanics will be described on the example of a single the application.

## **ANALYSIS OF GAMIFIED APPLICATION**

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For the analysis of gamified application Duolingo was chosen, which, together with Khan Academy (and many others like Code Combat, Read Theory, etc.) belong to popular gamified learning environments. While Duolingo focuses on the language acquisition, Khan Academy's focus is mainly on mathematics. Duolingo is completely free and users can help with further development. It comes as a web application and mobile application for each major platform on the market (iOS, Android and Windows). Both share similar user experience which is based on heavy use of gamification principles and mechanics.

It would be more appropriate to compare two or three applications or environments. However, the paper length is limited and the gamification elements tend to be similar. Previously mentioned representatives such as Khan Academy, Duolingo or Code Combat share the main idea and approach. Also, they are all open to community and their goal is not to be commercially focused. The development and use of these environments lies heavily on their user base. This is a big advantage in education environment, because we do not bear the burden of paid access. On the other hand, these applications are as good as the community makes them.

Due to its popularity, the gamification is also used in the paid education applications. They use different variety of game design principles and their analysis can be covered in the future work.

The analysis presented in the next paragraphs covers both game design principles and mechanics. It tries to capture the functionality explained on the Duolingo application. The reader should be able to understand the implementation of the gamification aspects based real usage of them. In the analysis there is often positive and negative impact explained according to how Duolingo succeeded in the implementation itself.

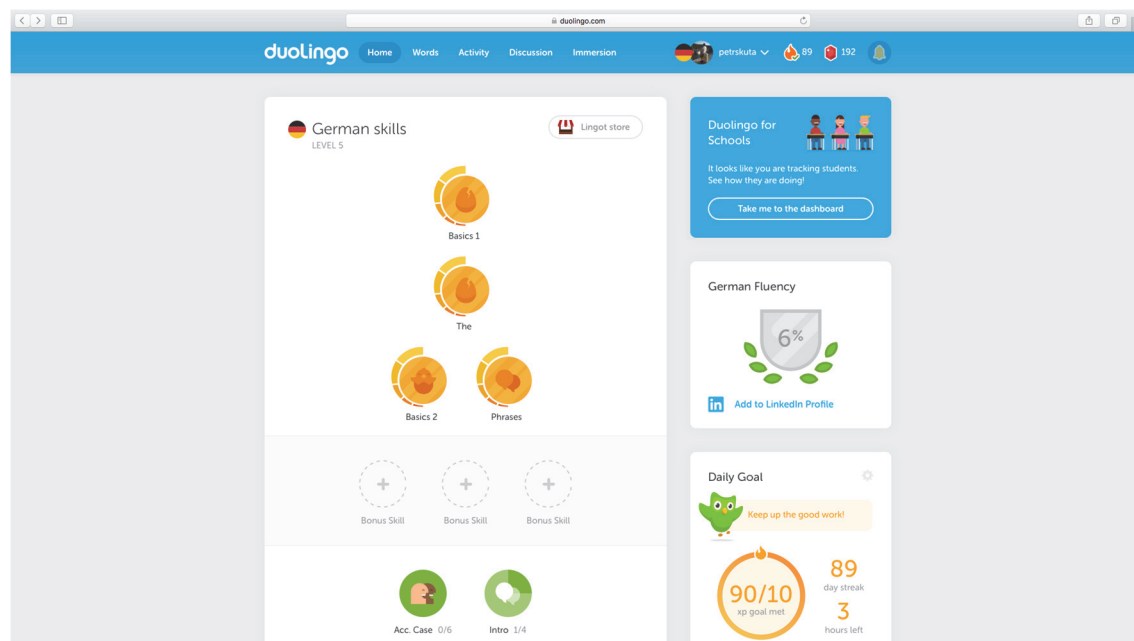


Figure 8: The interface of Duolingo web application

The user interface of Duolingo web application is shown in the Figure 8. Developers have decided to use two column design. The menu of the application is on the top together with status icons and access to a profile. In the left column we can see the content of the application – the lessons realized by colored icons. In the right column we can see other parts like badge of completion, daily goal, leader board and social networking field.

The content itself represents “Unlocking content” game design principle. From the start there are not many possibilities how to pass through. The student has to follow the already prescribed order. But later on he or she can actually choose which lesson he or she desires to do next or even often more lessons in the same row can be done at once. The icons of the lessons are colored. The gold color means the lesson has been successfully done and student knows all the vocabulary. If the lesson is started the color varies but it is always in the light tones and after passing individual parts of the lessons the tone of the color changes to the dark spectrum. Once it is completed it can be redone anytime student wants.

The developers of this application have also implemented so called “Streaks” and “Lingots.” These are representatives of “Virtual goods” game mechanics. They help to set “Goals” game design principle. Streak is achieved when the student successfully has passed his or her daily goal and is increased incrementally by one. But if student fails to achieve a daily goal, the streak is restored to zero. After every successive ten days of achieved streak the student is rewarded by Lingots. Lingot is the form of virtual money in Duolingo. They can be only obtained by active streaks or through completing lessons. Lingots can be spent for e.g. extra lessons like “Flirting phrases” or “Proverbs” and other extra material. The problematic aspect can be seen in the lack of extra material. Keen students can easily collect everything possible and run out of the motivation.

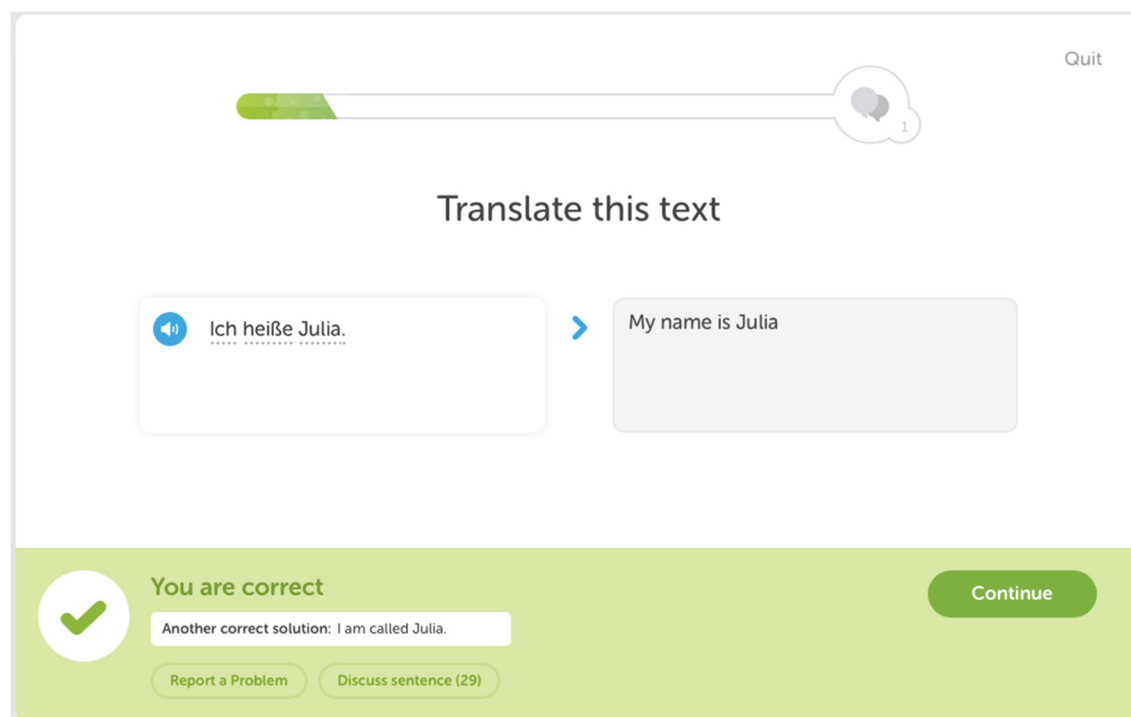


Figure 9: Active lesson

The next part of the analysis is the lesson itself. Each lesson consists of a number of sub-lessons. They can be done only in the set order. Active lesson is showed in the Figure 9. We can see a number of game design principles. The first of them and the most obvious is “Visible status” realized by “Progress bar.” The student can easily track the progress of the current lesson by seeing the color of the bar. The more colored the bar, the closer the student is to completing the lesson. This variant of progress bar is interesting because of another functionality: It was designed to be also a meter to show “Freedom to Fail” game design principle. If student makes a mistake the colored bar regresses, but if he successfully passes the color goes forward. Below the task and student’s answer there is another field placed. In this case it is “Rapid feedback” game design principle. It reacts to both student’s attempts either failure or success. If the student is successful, the background of the field changes it’s color to green and the big tick icon is displayed. Also, if there is another possible solution for the task it is shown in white field. But if the attempt was failure field’s color goes red and student can see a cross. The application then shows the correct solution. If the student thinks that his or her solution was correct he or she can use “Discuss sentence” button. This action shows discussion dialog where you the student can directly communicate with translators and other users and report mistakes or another possible solution for the task.

It should be stimulating that there is no penalty for failure. On the other hand, the progress forces the student to repeat the content until he passes some set line. It can happen, that this approach generates about forty or fifty attempts before the limit is successfully passed. This might lead instead of motivation to frustration. The only possibility how to pass the active lesson is to fulfill the goal or to quit. An improvement on this aspect would be appropriate.

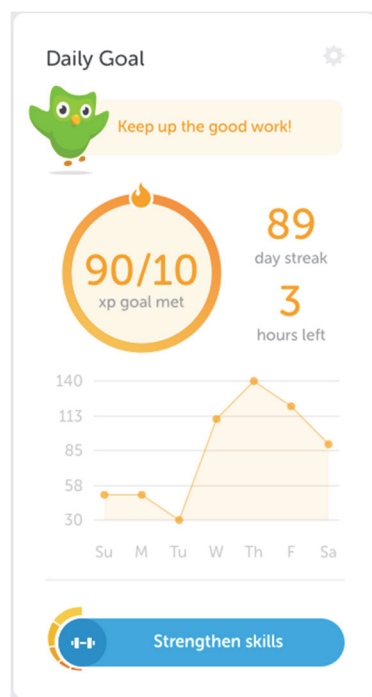


Figure 10: Daily Goal

Very important part of each learning environment is the motivation to keep going. While using the application, there is no real teacher, so the is expected to find the inner drive to keep studying on their own initiative. Duolingo provides a “Daily Goal” mechanism. It is a set of objectives describing how much the students desires to learn transformed into experience points (abbr. XP). Each lessons successfully passed adds ten XP points. After some milestone and obtaining enough XP points student’s level increases and he or she is rewarded by the same number of Lingots. Higher levels have slightly increased the cap of XP points needed to reach those levels; reaching them thus becomes more challenging. The panel also shows statistics so the student can track the progress. If he or she is about to lose the “Streak,” the system sends an email notification, or in the case of mobile application displays the notification right on the screen.

Social aspect is fulfilled by game mechanics “Leaderboards” through “Social Engagement” game design principle. The small table in the Figure 3 shows the record of the student and all other learners, which were added by him or her as a friend. The summary can be switched into weekly, monthly and all time. The leaderboard is more passive and informative rather than active aspect. It does not affect the learning process but for competitive persons can be stimulating if they see how they are doing in comparison with others.

The Duolingo contains even some other game design principles and mechanics like “Personalization” principle and “Avatar” mechanics. But they actually play a minor role in the use of presented learning environment.



## DISCUSSION

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As it has been shown, the Duolingo developers have used almost all gamification design principles and game mechanics at once. Therefore, not all of them are used by each student. It can happen that e.g. "Personalization" here presented by avatar Duo and its changeable clothes are completely omitted by some students. Others might not be interested in competing through Leaderboards etc.

An example of not finished concept in the Duolingo might be the principle "Virtual Goods." As mentioned previously student for reaching his or her goals the student is rewarded by Lingots. They can be spent for extra lessons, outfits for avatar (transferring it "Personalization" principle) and active boost which can help to earn even more Lingots. For keen and interested students, it is easy to obtain hundreds of Lingots, but the Duolingo fails to offer more stimulating stuff once the extra lessons and outfits are all unlocked.

While the positive aspects prevail, there are often the negative ones present. A problem is, how to minimize their impact in the implementation. Because the motivation is worked with and there is no real teacher to guide a student, the loss of motivation might have a big impact on the learning. As all the gamification principles and mechanics are used at once, the student can easily lose interest being overwhelmed by the heavily gamified environment itself. Maybe the gradual or sequential approach would be more appropriate.

It would be interesting if there was used some of adaptive mechanism (Kostolányová, 2012) known from adaptive forms of education. The learning environment the could suggest to student only some of the game mechanics based on the data of how they use the application and to which gamification design principle they are respond to. It would allow students to focus on game mechanics which stimulate them most and skip the others. However, completely removing the mechanics would not be recommended, because what is stimulating for the student at any given time is affected by many variables.

The suggestion of the authors is to implement the gamification together with adaptive approach. It could be the answer how to present the gamified principles and mechanics that student will respond to. The motivation could be stimulated only by the mechanics and principles suitable for each individual student. The paper's authors want to focus in this direction in their future work.

## CONCLUSION

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The paper presents the Gamification theory in education. It strives to trace the origin of the theory and current state of use. Then the idea of the Gamification theory as the fifth learning theory is proposed. Due to the non-existence of an established official terminology the paper choses one of the variants for the analysis. In the second part the analysis of gamified application Duolingo is presented. It is described from both gamification design principles and game mechanics. Their implementation is discussed in the form of the examples from application. In the last part paper suggests further research for the combination of adaptive methods and gamification methods.

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# Students' Teamwork in Moodle LMS Environment

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## Abstract

*Our contribution presents a method of teamwork in the online course Methodology of Stylistics and Communication at Primary School. This method was used in the preparation for pupils' retelling a text in their own words. The contribution describes how the interactive possibilities provided by a virtual environment can foster communication and collaboration during the actual learning process. The work on the group-based assignment brought a beneficial connection between learning the theory in an on-line course and gaining specific experience in teaching practice. Students learned not only from the on-line course texts but also through sharing their views and experience, and through collaborating in the group forum. The survey showed that negative feelings and stalling communication are natural in some stages of such team assignment. Nevertheless, the students themselves can identify some barriers to successful collaboration, such as the failure to allocate tasks or failure to honour the agreement on task allocation.*

## Keywords

*Teamwork. Online course. Stylistics and communication. Methodology of stylistics and communication. Collaborative and cooperative learning. Retelling text.*

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## INTRODUCTION

The document "National Qualification Framework for Higher Education of the Czech Republic" lists examples of general competences of graduates from higher education. The National Qualification Framework for Higher Education of the Czech Republic is an outcome of the national project Q-Ram under the Operational Programme Education for Competitiveness in which the expected knowledge skills and general competences were defined for higher education institutions and higher professional schools.

*The student is able to:*

- *Take decisions autonomously and responsibly, based on a general specification,*
- *Coordinate team activities on the basis of a general specification and allocated resources,*
- *Take into account relevant ethical aspects when solving a problem,*
- *Communicate the nature of technical problems to both professionals and laypersons in an understandable and convincing manner,*

- *Autonomously acquire further professional knowledge, skills and competences.*

The on-line course Methodology of Stylistics and Communication at Primary School is an opportunity for developing these competences in students. This on-line course – which is offered by the Faculty of Education of University of West Bohemia – is part of a blended study programme for trainee teachers for primary schools. The instructor meets the students face-to-face during the introductory tutorial at the beginning of the semester, specifies the course requirements, and provides guidance on navigating the virtual course environment in Moodle LMS.

The students must complete two assignments: an individual one and a team-based one. The first requires them to prepare their own lesson in stylistics and communication or, alternatively, submit a video sequence that shows their own teaching practice. As a team, they prepare a lesson plan and teach a lesson in which pupils loosely retell a chosen text. In the summer semester of 2015, we investigated the effectiveness of teamwork between students in this course. We monitored the communication and collaboration between them in their group discussion forum, evaluated the results of their teamwork, analysed their answers in the final questionnaire, and conducted interviews.

### **TEAM-BASED ASSIGNMENT AND RESEARCH SAMPLE OF STUDENTS**

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The assignment consisted of a series of tasks for the team: to select an appropriate source text for primary school pupils in their chosen grade, choose how to present it to the pupils, test it in practice, make audio recordings of three pupils' retelling the text, and analyse these pupils' performance in terms of accuracy of the content, their choice of lexical, morphological and syntactic elements, and speech aspects.

*"In this case, the assignment involves not only instrumental but also social aspects: a common strategy must be developed which both addresses the nature of the problem and reflects the goals and talents of the group; often there are other related matters (e.g. ethical questions) to be taken into account."* (Dlouhá et al, 2011)

The theoretical basis for the teams' work is the course chapter on retelling.

It is divided into the following sub-chapters:

- Relation between productive and reproductive writing styles,
- Types of retelling,
- Retelling exercise,
- Assessment of pupils' retelling performance.

The study materials include two audio recordings which illustrate the difference between pupils retelling without and with preparation. The chapter also contains an exercise in which the students in the course develop their ability to ask questions that help pupils understand the story's plot (Jiří Horák's fairy tale "John and the Willow Tree"). The students can compare their solution with two approaches suggested by course authors which are included but hidden.

At the beginning of the 2015 summer semester, there were 65 students enrolled on the course, of whom 62 eventually passed the exam. Final questionnaires were submitted

by 51 students. Fig. 1 is a plot of the age distribution of students in the course and Fig. 2 shows the length of their teaching experience.

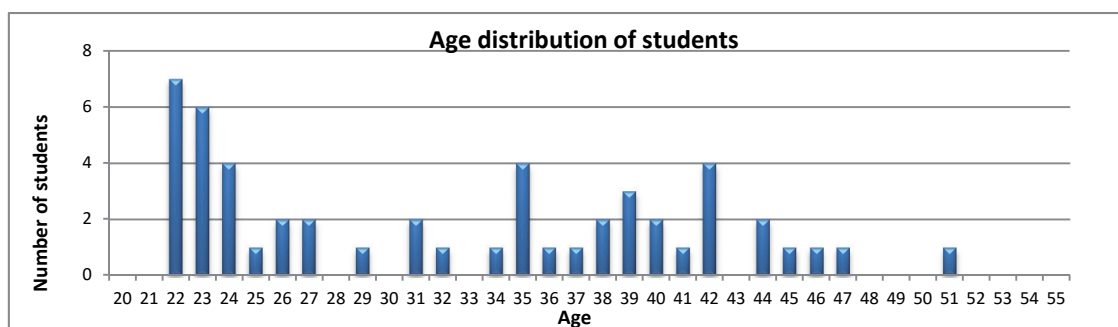


Figure 1

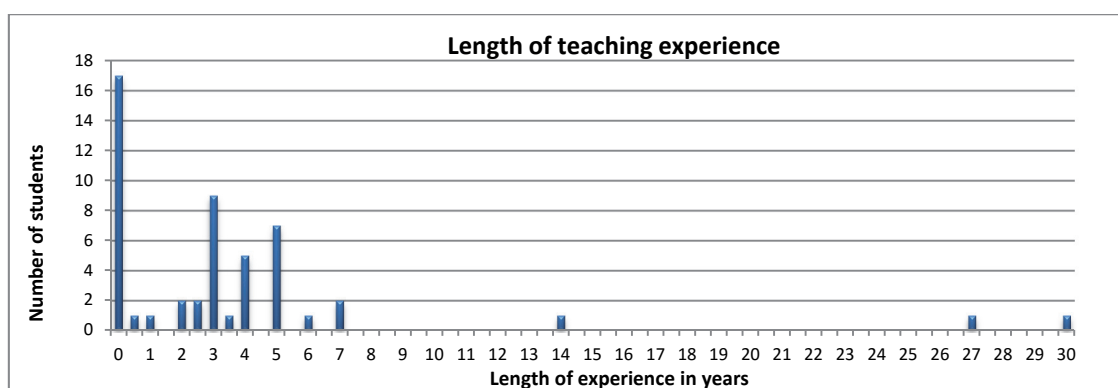


Figure 2

## FORMATION OF GROUPS

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At the introductory tutorial, the students were familiarized with the objective of the team assignment and invited to form self-selected groups of 4-5 members. A recommendation was given that the groups should be heterogeneous, each comprising at least one primary school teacher together with teachers of various ages and with various lengths of teaching experience.

Fig. 3 shows the students' views of the group-forming process. 72 % of students strongly agreed with the statement that their group had formed without any problems. In their questionnaires, students reported that they had formed the groups on the spot, during or just after the introductory tutorial, most often on the basis of friendships established in earlier courses. One fact which played a role here was that they had worked in such groups before – during their university studies – and this collaboration had proved successful. A recommendation was given that at least one group member should be a teacher or a teacher's assistant because part of this project was to take place during actual school instruction.

The questionnaires showed that the groups in which communication gradually deteriorated were predominantly those which had formed randomly and lacked strong social relations between their members. Respondents definitely saw friendly relations

between group members as a major advantage because of the trust between the members who could rely on one another. There was only one negative response in this regard. It referred, however, to the subsequent collaboration, rather than the group formation process itself.

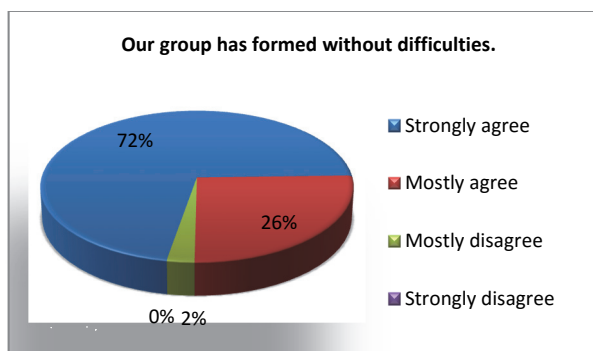


Figure 3

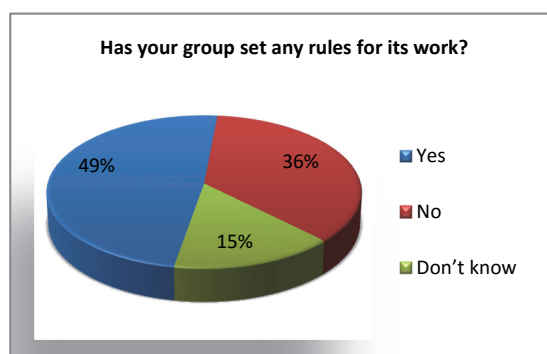


Figure 4

## ORGANIZATION OF GROUPS

Each group was invited to choose a name with which its members would identify.

49 % of students mentioned that they had established rules for their group while it was formed (see Fig. 4). In their questionnaires, the students reported that, in their opinion, an important key to the group's success was to set deadlines for completing and submitting parts of their team assignment.

Examples of rules:

*"1. This is about teamwork: let's try to meet the deadlines because otherwise we will not get anything done.*

*2. Because all of us are quite busy, I suggest that we should schedule the tasks into one-week blocks.*

*3. Make sure you communicate regularly in this forum (questions, comments or suggestions).*

4. *If you agree, I will assign the weekly tasks. But if there is a volunteer, I will be happy to let him or her do it.*"

Certain rules were followed even by members of those groups which had not set any explicit rules. Those students, too, rated their group's collaboration as successful.

Within the groups, tasks were allocated to individual members. Fig. 5 reports students' opinions on how the task allocation went in their group.

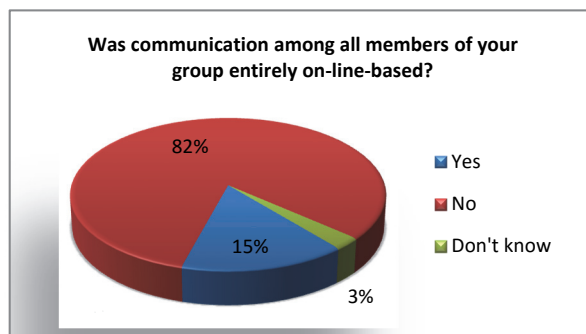


Figure 5

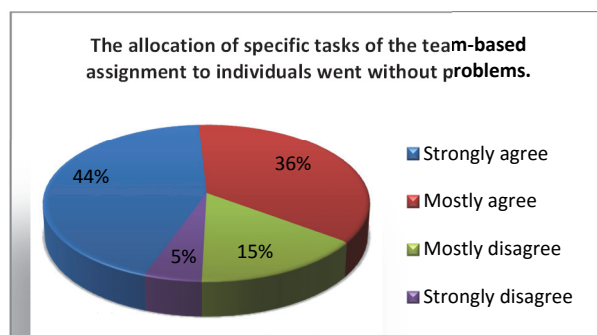


Figure 6

44 % of students strongly agreed with the statement that the allocation of tasks posed no problems, and that the tasks were simply chosen by students upon agreement in the discussion forum. One of the students wrote: *"We have not allocated tasks specifically. This was a major mistake!!!"* Some negative answers were accompanied by an explanation that when tasks were being allocated, some group members failed to get involved in the communication. Some *"disagree"* answers did not actually respond to the task allocation process but to the subsequent failure to follow this allocation.

*"Tasks were allocated all right but what happened then was that, for example, I had a task to do and the allocated time was not up yet but another member of the group completed it for me ahead of the deadline. This way there was duplicate work. This led to some disagreements – why did she complete that when she did not have to; and who is supposed to do what if we do not stick to the original plan."*

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## COMMUNICATION WITHIN GROUPS

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Communication within groups took place mainly in the discussion forum for team collaboration. In the system, the course instructor created groups based on students'



decision and set the "group mode" for the discussion forum. Individuals in the forum could therefore only see the posts submitted by members of their own group. The instructor could see the posts by members of all groups, track their teamwork from the beginning to its outcome, assess the contributions of individuals to the work of the group, and, if required, enter his or her comments, ideas, advice, suggestions, motivational tips, etc.

Fig. 6 indicates that a mere 15 % of students reported in their questionnaires that the communication among members of their group took place exclusively on-line, i.e. in the group's discussion forum. 82 % of students also reported communication during face-to-face encounters during classes at the faculty. Some of them even met outside the classroom, at home, talked on the phone, texted one another, and used social networks (Facebook). It turned out that the collaboration which took place exclusively in the virtual environment was not optimal. Reports of exclusive on-line communication came from those groups whose members eventually did not rate the collaboration as successful.

The instructor made an effort to act as a non-disruptive and supportive element in group discussions. Therefore, she monitored the discussions and entered them in the role of an advisor who poses thought-provoking questions, offers motivation, encouragement and answers students' questions. The tutor's motivational contributions were highly appreciated by students in their final questionnaires.

*"The tutor's contribution raised our spirits and gave us strength and optimism to continue our joint work." "I felt she was interested in the group. I believed that she was keeping track of our progress and would help us if something was unclear or if mistakes were made (which proved to be true)."* The instructor's role became more prominent in the final assessment of the results of teamwork.

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## CHOICE OF SOURCE TEXT FOR RETELLING

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Choosing an appropriate text for retelling was crucial for the outcome of group collaboration. Chapter Retelling of the on-line course informed the students that a text chosen for free retelling by primary school pupils should be short, dynamic, narrative and involving a simple and more or less closed-ended storyline with a small number of characters. Not all texts in the reading book meet these requirements. *"Reading books, however, have a completely different purpose than being collections of texts for retelling"* (Hubáček, 1999). Therefore, we believed that students should test their ability to choose a good source text for retelling, and validate their choice in practice as part of the course.

While selecting a text for retelling, the students debated the following topics in the group forum:

- The right length of the source text,
- Appropriateness of the source text for pupils of a particular age,
- Suitability or unsuitability of symbolic texts, those based on play on words, and phraseology and dialogue-based texts,
- Different variations on the same theme and their suitability for retelling,
- Benefits or drawbacks of altering the source text,

- Inadequacy of internet resources riddled with language mistakes and lacking information on the authors.

The discussion brought added value in that students opened the question of interpretation while choosing a suitable text for retelling.

*"Easter is coming and this theme will be reflected in reading. It is relevant to me on several levels:*

- *The writings of Zuzana Nováková give me goosebumps and I find them very charming.*
- *To what depth should we discuss themes from the Bible, especially considering the fact that I come from a strongly catholic family?*
- *Should we discuss Easter as the celebration of spring or as the most important Christian festival?*
- *Should children have at least basic knowledge of the key themes (e.g. the name of Jesus Christ, the name of his mother, the story of the Crucifixion...)?"*

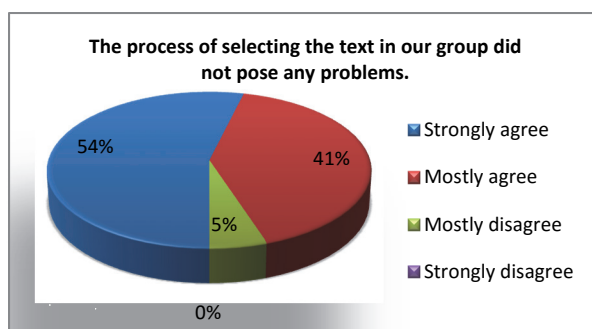


Figure 7

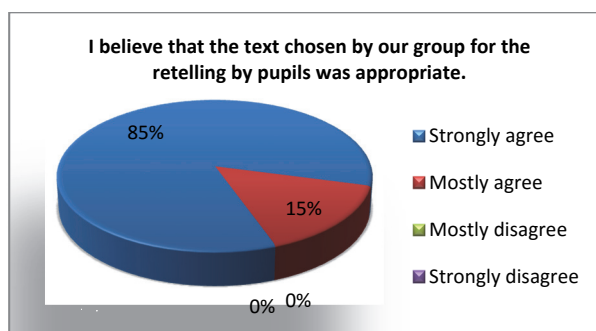


Figure 8

Fig. 7 indicates how smooth the text selection process within the group was in the opinion of the students. The main reason for 41 % respondents giving the response *mostly agree* was the fact that it took a relatively long time to choose a suitable text. However, the same reason led to the *mostly disagree* answer (5 %). In their answers to open-ended questions, the students praised their decision not to choose the first source text which was suggested, saying the collaboration thus paid off. They also appreciated the opportunity to have their say about all the texts suggested. One of the groups took a vote and chose the source text for retelling unanimously.

85 % students believed that the text chosen by their group for the retelling by pupils was appropriate (see Fig. 8). The main reason for the approval of their own choice was that the text was appropriate for the target age group.

*"What we took into account in the first place was the age of the pupils. The choice proved to be correct."*

Other reasons for being completely satisfied with the choice concerned qualities of the texts, which were referred to as absorbing, interesting, plot-based or full of adventure and humour.

*"We chose the classical Czech fairy tale The Rich Man and the Poor Man, the theme of which I find very up-to-date. I liked the unusual words and expressions which also helped expand children's vocabulary. The fairy tale was easy to understand and its storyline was attractive."*

The quality of pupils' performance on the recordings showed that "Tom Sawyer Whitewashing the Fence" (by Mark Twain), which is included in a reading book for 6<sup>th</sup> grade, can be retold well even by 4<sup>th</sup> grade pupils. Good retelling performances were the result of diligent preparation within the group and the good work of the instructor.

The texts chosen by the 14 groups spanned across various genres of literature: fables, folk-tales, fairy tales, stories of adventure, and stories with children or animals as the main characters.

## **PRESENTING TEXT TO PUPILS AND RECORDING THEIR RETELLING PERFORMANCE**

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In the next part of the team assignment, the students were required to prepare a lesson plan for presenting the source text to the pupils. They were recommended to reflect the needs of both visual and auditory learners. They were also required to come up with ways of explaining unknown words. Finally, they were also recommended to split the text into parts and have the pupils first retell the separate parts.

The approach to explaining words which could be expected to be unknown to the pupils varied among the groups. Most of them chose discussion between the teacher and the pupils, others developed PowerPoint or SMART Notebook presentations with visual materials explaining the meaning of the words. One of the groups used an explanatory dictionary and another prepared a guessing game with three options for each word. In one group, the students developed a worksheet for the pupils.

One benefit of collaborating in a virtual environment is the opportunity to publish audio or video recordings of working with pupils as they familiarize themselves with the source text. Thanks to this, even those students who could not attend the retelling preparation lesson were informed about its progress. The on-line environment thus facilitates virtual class observation.

*"I had confidence in the method I had chosen but I was grateful for the comments which were fully constructive and useful for my future work."*

Fig. 9 demonstrates that 59 % of students strongly agreed with the statement that the process of presenting the source text to pupils was handled well by their group from the methodological perspective.

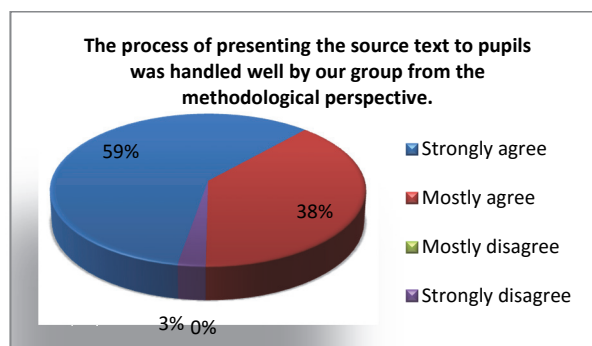


Figure 9

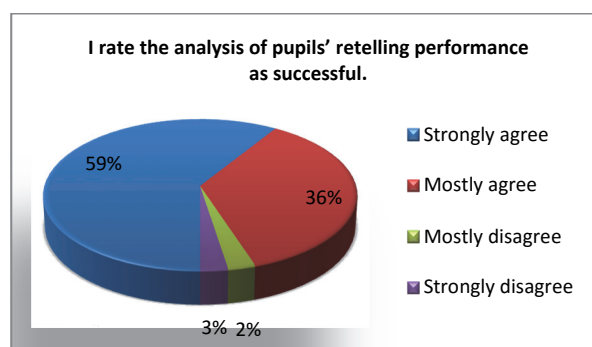


Figure 10

## ANALYSIS OF PUPILS' RETELLING PERFORMANCE

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The above-described tasks and sharing activities were followed by an analysis of pupils' retelling performance. The goal of the analysis was to find whether the choice of the source text and the preparation for retelling were appropriate, to highlight problems, and to derive general conclusions and transfer the findings. In terms of **accuracy**, the students evaluated the accuracy of the retelling content with regard to the source, the pupil's ability to distinguish between important and unimportant aspects, and the amount of functionless or redundant features in the retelling performance. With regard to **vocabulary**, the students focused on how inventive pupils were when choosing their means of expression, whether the synonyms used were adequate in terms of both meaning and style, and looked for the use of redundant words, e.g. demonstrative pronouns. With respect to **syntax**, the students evaluated how well the pupils had used direct speech to make retelling livelier in accordance with the source text; the students also checked for convoluted sentence structures, and for mistakes in sentence construction. **Morphological** aspects involved questions whether the use of particular word forms was in accordance with the source text. When assessing the **speech quality**, the students focused on how precisely the pupils pronounced the words, whether they

omitted phones or made unnecessary pauses and whether they used correct sentence intonation and word and sentence stresses.

For this analysis, the students had to refresh their knowledge of various disciplines of current Czech linguistics. They were often unclear about classifying a particular aspect into the appropriate language category. In their questionnaires, they reported that *"The descriptions of individual language categories given by the tutor before analysing the retelling performance were an immense help"*.

The very good retelling performance of the pupils was attributed to the high-quality preparation. *"The children experienced a different way of working in their lessons and enjoyed it. For me this was a gratifying and motivating experience for my future work."*

As Fig. 10 indicates, a clear majority of respondents rated the final analysis of pupils' retelling performance as successful. 61 % of students expressed strong agreement with the statement "I rate the analysis of pupils' retelling performance as successful", while 36 % students mostly agreed with the statement. The only negative response came from the group in which communication had been weak from the start.

## ASSESSMENT OF COLLABORATION WITHIN GROUPS

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While a group is working on an assignment, it is natural that at some point negative emotions surface and communication begins to dwindle. In our course, such occurrence admitted by 51 % of respondents. Where the collaboration takes place in a virtual environment, trust can be built on not only social relations but also reliability. Negative emotions were triggered by failure to meet deadlines, by long waiting for responses from group members, and by some members' involvement in communication only after repeated requests. During the semester, one student quit her study programme which threatened her group's work. The respondents mentioned that *thanks to tutor's intervention, things calmed down again*. As the questionnaires showed, negative emotions set in mainly at the final stage of the project when participants were under time pressure and had to deal with various irregular events in their teaching practice, such as outdoor weeks, Czech School Inspectorate visits, preparation of summer camps, and others.

*"The difficult part was the final summary, for which each of us contributed their observations but there was no one to compile and arrange them."*

Only two groups were reported by the students to have poor communication from the start. Negative ratings were also caused by insufficiently constructive posts by colleagues.

*"I had negative feelings about others communicating by way of 'That it awesome', 'Cool', or 'OK'!!!"*

Fig. 11 shows students' view of the success of collaboration within their group.

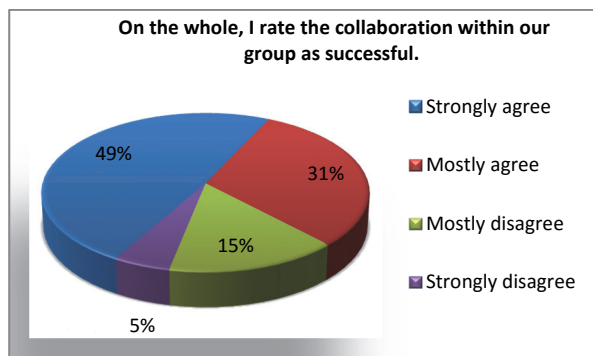


Figure 11

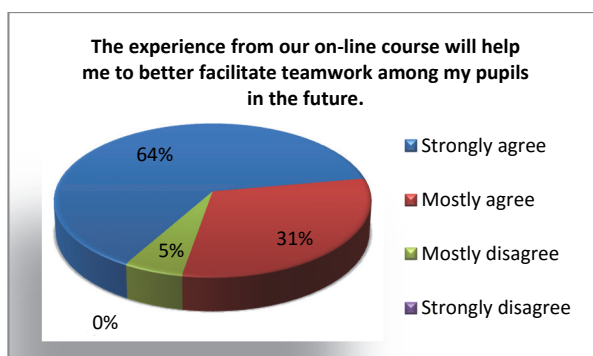


Figure 12

Those who strongly agreed (49 %) or mostly agreed (31 %) with rating the collaboration in their group as successful reported no communication problems in their answers to open-ended questions. *"Our mutual liking survived the distance between us and there were no communication problems, which means the whole thing was a success to me."* *"The collaboration with all members of the group was excellent. There were no disputes or conflicts. Everyone completed their task in time and successfully."* *"Everything went smoothly; and even those who did not communicate at first joined in eventually."* *"I believe we worked as a team and except for some minor lapses it was a great work."*

Of the total number of 14 groups, some negative responses were submitted in 5 groups. In two of those, it was only one member who expressed her disagreement.

The main issue for those who gave negative answers was the insufficient engagement of some of their colleagues.

*"Of the five-member group, only two of us worked together actively and meaningfully. On the other hand, this collaboration was lovely, fun and, above all, useful."* These students who worked together believed that the cause of this group's failure was that tasks had not been allocated at the start. A third member of this group wrote: *"The collaboration within our group went very well, thanks mainly to our colleagues M. and J. who became the coordinators of the group."*

One of the respondents explained her *mostly disagree* response to the question on the success of the collaboration by the absence of deeper thoughts on the topics discussed in the group's forum.

In one of the groups, the communication stalled. One of its members acted in a domineering way, took the leading role and disrupted the communication and collaboration within the group (e.g. by ordering what other group members "may and may not" write in the group forum).

*"Due to one person, most people lost interest in posting their contributions." "I would rate our collaboration as non-existent. I would not want to return to this group. One was afraid to write anything for fear that it would be labelled as wrong."*

It can be seen as a positive outcome that 64 % of students strongly agreed and 31 % mostly agreed with the statement that the experience from the on-line course will help them to better facilitate teamwork among their pupils in the future (see Fig. 12).

## CONCLUSION

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The work on this group-based assignment brought a beneficial connection between learning the theory in an on-line course and gaining specific experience in teaching practice. Students learned not only from the on-line course texts but also through sharing their views and experience, and through collaborating in the group forum. One advantage was the opportunity for the students with no experience to work with those who had teaching experience of various lengths. Preparing and conducting a lesson in which pupils freely retell a source text proved to be an appropriate topic for team collaboration among students in an on-line course. As the group deals with a task, a number of ideas and suggestions are put forward. Students are more successful in identifying wrong solutions themselves. In the virtual environment, video sequences or audio recordings from the class can be shared. Therefore, those group members who could not attend lessons where part of the team-based assignment was completed, still had the opportunity to conduct virtual class observation. An advantage for the course instructor is the possibility to monitor the collaboration within the group in various phases of the team assignment and assess the contribution of individuals to the teamwork.

The survey showed that negative feelings and stalling communication are natural in some stages of such team assignment. Nevertheless, the students themselves can identify some barriers to successful collaboration, such as the failure to allocate tasks or failure to honour the agreement on task allocation. Collaboration was not successful in those groups in which no closer social relations between members had formed. In addition, a domineering member of a group can completely disrupt the communication. The instructor can identify and help mitigate or even eliminate a number of problems in the groups' teamwork. However, large numbers of students and teams in an on-line course are a major obstacle in this context. When there are 14 groups, it is not easy to detect stalling communication within them or make sure that all members contribute to the group's work, an issue which would be less challenging with fewer groups in the course.

In our research, we only focused on the group discussion forum. Our future research efforts will also map the effectiveness of other LMS Moodle collaboration tools, such as the workshop activity which includes a peer review feature, or the Moodle database activity.

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# Optimization of the Method for Selection of Questions into the Repeated Electronic Test for the Purpose of Teaching and Evaluated Testing

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## Abstract

*Optimization of selection of questions into the test from a larger set of issues is a problematic topic, often solved in test systems, which is usually processed only by simple random sampling. An original proposal of a sophisticated selection method customized to the test applications will be presented in this article in detail. The principle is based on a modern version of the theory of forgetting. This theory is modified by the possibility of determining the period of testing and it is also complemented by the knowledge factor. The probability of selecting each of the questions into the test are then determined from the combination of these components according to the principles of genetic algorithms. Thanks to this method, tested users are presented more often with such questions the topics of which these users don't have sufficiently fixed in their memory, and those they should revive again. In evaluated testing, this method can check with students whether they already have learned the theme, which they did not know the last time. This model can be an inspiration not only for the implementation of future testing applications but also for further development of the theory of choice functions, either in this or an entirely different science branch.*

## Keywords

*Test. Forgetting curve. Spaced repetition. Choice function. Ebbinghaus. Genetic algorithm.*

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## INTRODUCTION

One of the main components of testing throughout the Universal Testing Environment<sup>1</sup> is the ability to assemble an original test with randomly selected questions. The number of questions that are to constitute the individual tests, is usually smaller than the number of questions that are available for the test. Questions for each test launch are randomly selected from such a database. It may be a selection of e.g. 6 out of 8, but also out of 100 questions. However, this choice may not only be completely random, but in some cases it is desirable to be able to influence the randomness of selection of questions in order to better fulfill the purpose for which the test is used. The purposes that require

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<sup>1</sup> Universal Testing Environment is an electronic online testing system designed for the creation, operation and administration of the tests, independently or in a cooperation with LMS (Voborník, 2012b, 2014).

different types of mixing comprise e.g. educational tests, training (drill) tests, repeated or evaluated tests etc. (Voborník, 2011)

Totally random mixing is needed in the final evaluated test. New questions still unresolved by the tested user should be favoured for educational testing. In case of the training tests, questions that have already been used should be repeated at specific intervals according to the individual forgetting curve of each tested user. When questions are selected for a recurrent test, the rate of accuracy of the previous solutions of each question and the time since this solution should be taken into account, adequately. And solely this last case will be discussed in this article.

Repeated testing combines a certifying and continuous educational tests (Chráska, 1999, p. 16). These tests should quickly and objectively examine knowledges of tested users (students) (Schindler, 2006, p. 23). On favourable conditions, these tests should be entered in regular periods, optimally at each lesson. The test should primarily include the topics covered in the previous lesson, but also older topics, that should be partially represented in the test (Hubálovský, 2012). It obviously applies only in certain subjects where these tests are used not only for examining of the current state of knowledge of students, but also as a motivation for continuous learning and preparation for teaching.

## **SELECTION OF TEST QUESTIONS**

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Several factors must be taken into account for optimal choice of questions for the repeated test which is entered periodically. These factors should influence the probability of selection, but no question shouldn't be completely excluded from the possibility of being selected for the test (Šedivý, 2014). These factors include a number of solutions of the question in the past, the time elapsed since these solutions and the achieved results (Voborník, 2012a). Suitable combination of these factors for the optimal choice of questions will be the main subject of this part.

### **Forgetting factor**

The time elapsed since the previous solution of the question is taken into account by the forgetting factor. The assumption is that a question entered recently has a higher probability that it will not be included in the new selection, rather than a question that was solved earlier.

Offsetting the impact of this time can be ensured by the *forgetting curve*. The shape of this curve roughly corresponds to the requirements for use and it also has its scientific basis in the psychology area (Atkinson, 2003, p. 280). The author of this theory is H. Ebbinghaus (Plháková, 2006, pp. 94–96). He states in his work (Ebbinghaus, 1885), that forgetting has the fastest progress in the early hours after learning a particular fact. Up to 80% of knowledge is lost until the next day (Scandura and Brainerd, 1978, p. 201).

The mathematical model of the forgetting curve is also used in educational software, which teaches users by the training (drill) method, i.e. by repetition of facts with a suitably selected delay between each rep (*spaced repetition*, (Kerfoot et al., 2007; Pavlik and Anderson, 2008)).

Also the *Re-wise* method used e.g. by LANGMaster (LANGMaster, 2012) is based on this theory. This curve assumes that newly learned facts are forgotten exponentially, but as opposed to the original approach, only one half of the currently memorized facts is forgotten in the scope of one day. Thus, if we ignore the effect of repetition, individuality of each person and their relationship to various facts, this forgetting curve according to the *Re-wise* method is expressed by Equation (1) and is shown in a graph on Figure 1. (Stára, 2010, pp. 20–21)

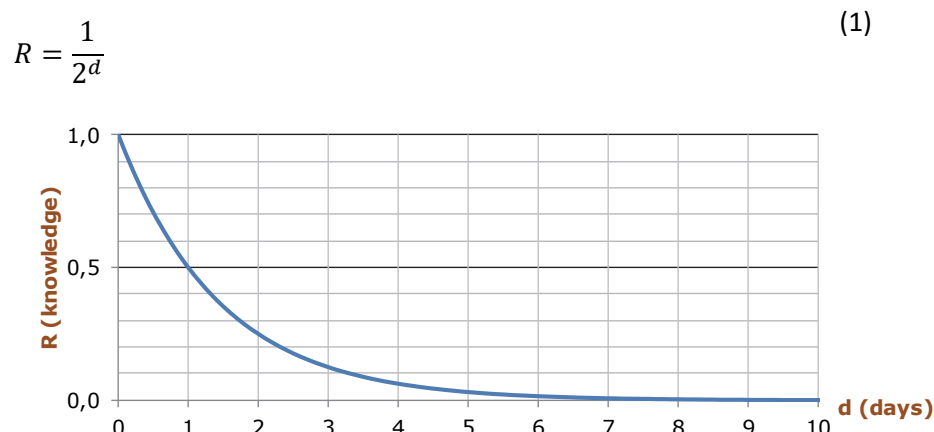


Figure 11: Forgetting curve according to the *Re-wise* method (1).

However, this version of the forgetting curve is decreasing too fast. The balance of the memorized knowledge is estimated to 6.25% after four days, and only to 0.78% after seven days. This curve, having such a fast crowding out time effect, is so inapplicable for solving of the model of selection of issues, because it offers almost no reflection for the usual weekly intervals of the courses. Exponent denominator  $d$ , which indicates the number of days elapsed since learning of the observed fact, could be for example divided by a certain value and thus relieve the initial steep decline, but the curve still remains too steep to achieve the desired effect even after this modification.

Because an evaluated repeated test does not aim to teach the tested users but rather periodically verify their knowledge, the forgetting component is not possible to be used in any of the above versions. The proposed mathematical model influencing a choice of questions therefore does not come out directly from the forgetting curves (Mohamad and Maurice, 1997) but it tries to better reflect the needs of permutations of questions for covering the entire spectrum of the tested curriculum. The time variable was therefore moved to the denominator (2) instead of geometric series. This change represents a distinctly flatter curve (more slowly declining) for the forgetting factor  $t$  than in the previous cases (see graph on Figure 12).

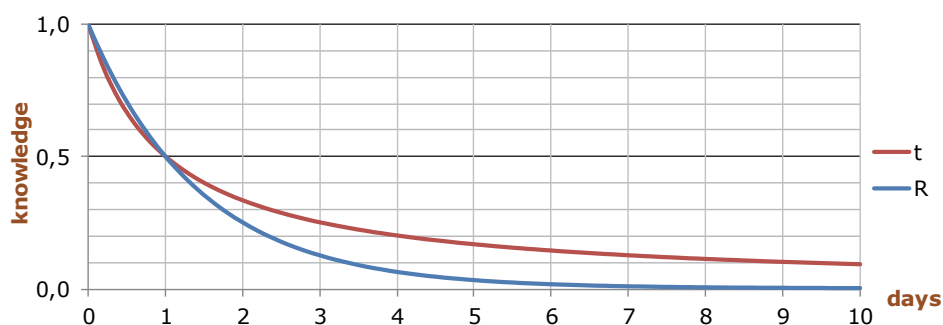


Figure 12: Comparison of the forgetting curve **R** (1) and the proposed curve of the forgetting factor **t** (2).

$$t = \frac{1}{d + 1} \quad (2)$$

The forgetting factor **t** expresses the rate of forgetting over time in the half-closed interval from 0 (no knowledge) to 1 (full knowledge): (0, 1]. Equation (2) was subsequently complemented by a parameter **p**, which allows to adapt the descent speed of the curve to a period of repetition of the test to the Equation (3).

$$t = \frac{p}{d + p} \quad (3)$$

Parameter **p** is the average period between individual tests expressed in days (e.g. 7 means “once a week”). The literal meaning of the parameter **p** is: “The number of days when the question, which was answered correctly (100%) in previous test, has only 50% probability for selection into the new test compared to new questions.” Graph on the Figure 13 shows the course of the individual curves **t** for three different values of the parameter **p**.

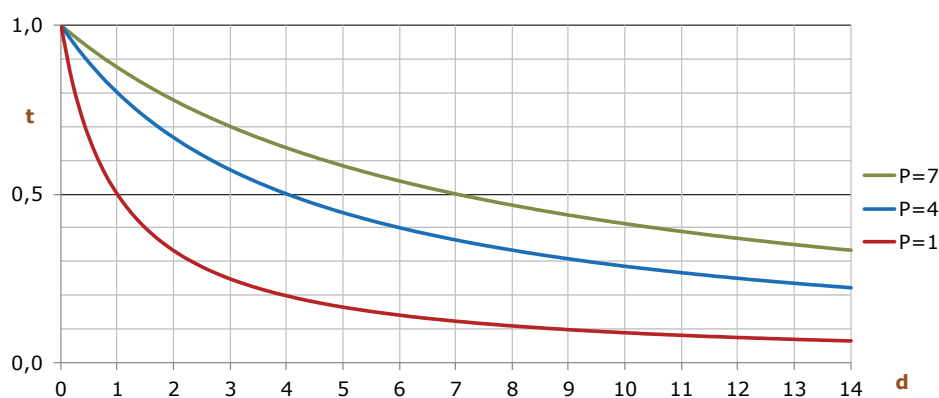


Figure 13: The progress of curves **t** for various values of **p** by equation (3).

## Knowledge factor

Another factor that is essential for choosing questions is their previous result. Unlike learning simple facts, which usually have only two-state result (know – not know), the result of solving individual questions is the real value of the fuzzy scale interval [0, 1].

*Knowledge* which the concerned user gained thanks to the solution of this question is still necessary to be added to the result. Detailed analysis of the solutions of individual questions can follow after completion of the test. In this analysis, the tested user can learn what he had done wrong and how and why it is correct. With this feature, the user's knowledge of the question rises above the zero level, although his/her answer might have been completely wrong (0%). Parameter  $n$  is included in the calculation which expresses the "learning from own mistakes" (see equation (4) derived from the classical linear equation of a straight line in the plane (Vošický et al., 2007, p. 81)).

$$v = (1 - n) \cdot s + n \quad (4)$$

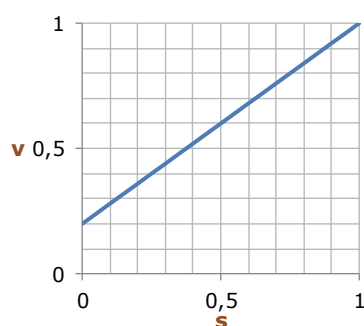


Figure 14: Relationship between values  $v$  and  $s$  for  $n = 0.2$ .

Equation (4) determines the degree of anticipated knowledge of the topic of the question  $v$ , after answering and displaying the analysis (feedback). The variable  $s$  in the equation represents the score obtained for the question answered  $d$  days ago. The value  $v$  is therefore increased by the portion  $n$  so that the result is again in the range  $[0, 1]$ . The graph in Figure 14 shows the relationship between these two values ( $s$  and  $v$ ) for the value of  $n = 0.2$ .

Therefore, the better was question was answered ( $s$ ), the better the fixed knowledge. In addition, the knowledge is relatively reinforced by the factor of learning from own mistakes ( $n$ ) due to displaying correct answers after the test.

## Weights for the selection

Previous two calculated values, i.e. the forgetting factor  $t$  (3) and the knowledge factor  $v$  (4) are subsequently combined by their multiplication into the value  $z$  (5).

$$z = t \cdot v \quad (5)$$

The result  $z$  is the current estimated knowledge of the question topic, according to its previous solution. If the question has been solved at least once, then it is always  $t > 0$  and when  $n > 0$ , it is also  $z > 0$ . This relation is shown in the graph in Figure 15.

If the question has been solved several times ( $c$ -times), this equation can generally be broken down for the  $i$ -th solution ( $i \in \{1, 2, \dots, c\}$ ) as follows (6).

$$z_i = \frac{p}{d_i + p} \cdot [s_i \cdot (1 - n) + n] \quad (6)$$

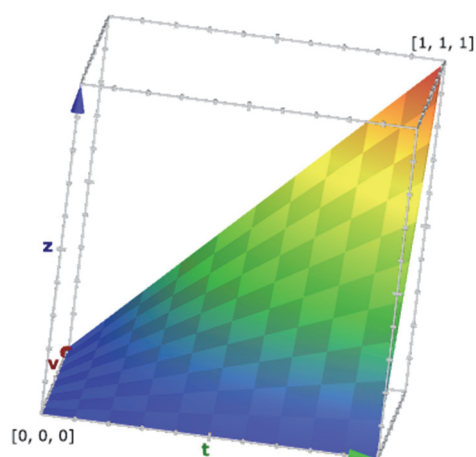


Figure 15: 3D chart showing the current knowledge  $z$  depending on the know-ledge factor  $v$  and forgetting factor  $t$  (created on google.com).

The calculation of the total value of current knowledge  $Z$  of the question for two previous solutions ( $c = 2$ ) can be realized in the same manner like merging of probabilities of two independent events (7), while the result is still in the interval  $[0, 1]$ . (Ross, 2009, p. 6)

$$P(A \cup B) = P(A) + P(B) - P(A \cap B) \quad (7)$$

Calculation of rate of the expected current knowledge of the question  $Z$  should be specifically shown as follows (8) for the two previous solutions ( $c = 2$ )  $z_1$  and  $z_2$ .

$$Z = z_1 + z_2 - z_1 \cdot z_2 \quad (8)$$

Equation for merging of probabilities of  $n$  events for multiple solutions ( $c > 2$ ) has the following form (9) (Ross, 2009, p. 6).

$$\begin{aligned} P\left(\bigcup_{i=1}^n A_i\right) &= \sum_{i=1}^n P(A_i) - \sum_{i=1}^{n-1} \sum_{j=i+1}^n P(A_i \cap A_j) \\ &+ \sum_{i=1}^{n-2} \sum_{j=i+1}^{n-1} \sum_{k=j+1}^n P(A_i \cap A_j \cap A_k) + \dots \\ &+ (-1)^{n+1} P\left(\bigcap_{i=1}^n A_i\right) \end{aligned} \quad (9)$$

However, instead of the direct calculation, a computationally less demanding gradual merging of probabilities of events can also be used. The equation (10) shows it for the three independent events ( $A$ ,  $B$  a  $C$ ) (Ross, 2009, p. 6).

$$P(A \cup B \cup C) = P(P(A \cup B) \cup C) \quad (10)$$

Probabilities of first two events are combined in the first step and then the third of them is added to this result the same way. The value of  $Z$  can also be calculated using the function with recursion (11), where its input parameter  $x$  equals to  $c$ , i.e. the total number of solutions of a question by a user. For this recursive computation, it is defined that  $f(0) = 0$ , i.e. if the user has never addressed this question ( $c = 0$ ), the result of this function and hence of  $Z$  will be equal to 0.

$$\begin{aligned} f(x) &= z_x + f(x-1) - z_x \cdot f(x-1) = z_x + (1 - z_x) \cdot f(x-1) \\ f(0) &= 0 \end{aligned} \quad (11)$$

The total current knowledge of the question  $Z$  (when the user addressed this question  $c$ -times) is thus determined by the above function with  $c$  as an input parameter (12).

$$Z = f(c) \quad (12)$$

The weight for inclusion of the question into the selection, which will be denoted as **P**, is then the supplementary value (negation) of the presumed knowledge of the question **Z** (13).

$$P = 1 - Z \quad (13)$$

The **P** value expresses the weight for the selection of the question into the test. This weight is equal to one for questions yet unsolved and the other (solved) questions have a lower weight ( $P < 1$ ). Because one tested user does not write more tests at the same time, forgetting factor **t** will always be less than 1, so in practice **P** will never equal to zero ( $t < 1 \Rightarrow Z < 1 \Rightarrow P > 0$ ). As a result of this, no question will ever be completely eliminated from choosing.

Table 2 shows the procedure for calculating the value **P** for a question that has been solved by a tested user four times, in mentioned dates, and with these results **s**. The value of **Z** is calculated cumulatively, i.e. by a sequential summation of the current **z<sub>i</sub>** with **Z** calculated in previous steps. The final **Z** is presented in the last row of the table and the value of **P** is directly derived from it.

Table 8: Example of calculating the value of **P** (13) for one question.

Date of solution	<b>d</b>	<b>t</b>	<b>s</b>	<b>v</b>	<b>z</b>	<b>Z (cumulatively)</b>
	now - date	$p/(d + p)$	score	$(s + n)/(1 + n)$	$t \cdot v$	$Z + z - Z * z$
2016-01-25 10:30	8.063	0.465	<b>0.8</b>	0.840	0.390	0.390
2016-01-19 12:00	14.000	0.333	<b>0.5</b>	0.600	0.200	0.512
2016-01-12 11:05	21.038	0.250	<b>0.3</b>	0.440	0.110	0.566
2015-09-25 09:00	130.125	0.051	<b>0.4</b>	0.520	0.027	<b>0.577</b>
Calculated for: now = 2016-02-02 12:00; p = 7; n = 0.2				<b>P = 1 - 0.577 = 0.423</b>		

## Selection of questions through weights

Assembling of the test is carried out by random selection from all available questions. The probability of selection of any one of them is directly derived from the value of **P**. The same selection algorithm is used in genetic algorithms for *selection of individuals* and is known as the *roulette wheel selection* (Maulik et al., 2011, pp. 28–29). In this procedure, a circular sector is assigned to each question, the area of which is proportional to the probability of selection of the question **P** (Hynek, 2008, pp. 22–23) (see sample of roulette wheel as a pie chart on Figure 16 compiled on the basis of the values from „*sahre*“ column in Table 9). Subsequently, an imaginary roulette wheel is spun and selected is the question on whose section „roulette ball“ stops (Jedlička, 2006, p. 6). The selected method of selection is suited for this job because there is no limitation of its deficiencies, such as the requirement for non-negativity solutions (Krpata, 2010, p. 23).



Table 9: Sample calculation of sizes of sectors for a roulette.

Question	P	Share $\frac{P_i}{\sum P}$		P cumulatively	Interval
1	0.375	0.108	11%	0.375	[0.000, 0.375)
2	0.980	0.282	28%	1.355	[0.375, 1.355)
3	0.412	0.118	12%	1.767	[1.355, 1.767)
4	1.000	0.287	29%	2.767	[1.767, 2.767)
5	0.213	0.061	6%	2.980	[2.767, 2.980)
6	0.500	0.144	14%	3.480	[2.980, 3.480)
$\Sigma$	3.480	1.000	100%		

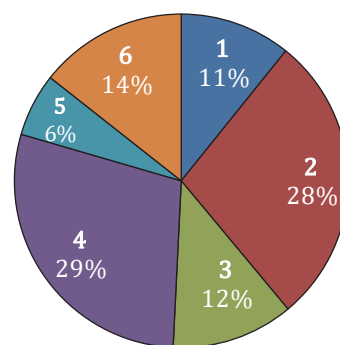


Figure 16: Sample of roulette as a pie chart.

The above-described *spinning roulette wheel* can be programmatically implemented by many ways. One of them is to use the accumulated values of  $P$  of individual questions as the upper limit of the individual sectors of the roulette (see the last column in Table 9). Subsequently, a pseudorandom value within the range of  $[0, 1)$  from the uniform distribution will be generated and then multiplied by the sum of  $P$  ( $\sum P$ ). The result of this procedure is a value in the range of  $[0, \sum P)$ , which directly fits into one of the intervals defined by these cumulative values.

For example, the result of multiplication of a random value 0.725 and the sum of the probabilities ( $\sum P$ ) 3.480 is 2.523. This result fits into the interval  $[1.767, 2.767)$  (see the *interval* column in Table 9). By this procedure the question no. 4 would be selected into the test.

The same question may not occur more than once in the same test, unlike selecting individuals for crossover in genetic algorithms. For the selection of the next question is thus necessary to repeat the whole procedure again, without the selected question.

## GROUPS OF QUESTIONS

The above described procedure applies to the questions that have an equal probability of selection in the first test for a tested user ( $P = 1$ ). However, in tests it is desirable that particular groups of questions were represented in a predetermined count (e.g. 4 questions on the topic of last lesson and 1 with any previous topic). For this purpose, some testing applications support classification of questions into groups, which also defines the count of questions determining their maximal representation in the test.

The Universal Testing Environment has a hierarchical structure of these groups and the depth of levels of this hierarchy is unlimited (see Figure 17). In this case, selection of questions for the test is performed by using a depth-first search algorithm (Bonet and Geffner, 2006). The set of questions with the defined count is selected from each group which is not further subdivided, using the process described above. This group is then cancelled and the selected questions are moved to a higher folder. This procedure is repeated until the top (root) group is reached, and the questions from this group are then selected for the current test.

Question name	Level	Weight	Always	Questions count	Time limit
[-] Cycles - outputs	5		<input type="checkbox"/>	1	
[-] ? Output variables - while	5	5	<input type="checkbox"/>		
[-] ? Output variables - for	5	5	<input checked="" type="checkbox"/>		00:02:00
[+] Cycles - WordBox	5		<input type="checkbox"/>	1	
[-] Conditions			<input type="checkbox"/>	3	
[+] If - outputs	4		<input type="checkbox"/>	1	
[+] Execute commands	4		<input type="checkbox"/>	1	
[-] Expressions - multiselect	4		<input checked="" type="checkbox"/>	1	
[-] ? Boolean expressions	4	6	<input type="checkbox"/>		
[-] ? Commands validity	4	6	<input checked="" type="checkbox"/>		
[-] Assigning	1,4		<input type="checkbox"/>	1	
[-] ? Complete branching	4	4	<input type="checkbox"/>		
[-] ? Principles of algorithms	1	2	<input type="checkbox"/>		00:01:30
[-] Shifting and swapping	3		<input type="checkbox"/>	1	
[-] ? Swapping variables	3	2	<input type="checkbox"/>		
Count=30		Avg=3,17			

Figure 17: Sample of hierarchical division of questions into multilevel groups for the *Algorithms* test in the administration interface of the Universal Testing Environment.

## CONCLUSION

Selection of the questions for the compilation of periodically repeating tests may be completely random. Also it may be a sophisticated process which will increase their usability. One of these models has been introduced in this article.

The principle is based on a modern version of the Ebbinghaus's theory of forgetting (Strnadová, 2011). This theory is modified by the possibility of determining the period of testing and it is also complemented by the knowledge factor. The probability of selecting each of the questions into the test are then determined from the combination of these components according to the principles of genetic algorithms. Thanks to this method, tested users are presented more often with questions the topics of which these users don't have sufficiently fixed in the memory, and they should therefore revive it again. For evaluated testing, this method can check whether the students have already learned the theme, which they did not know the last time. In combination with an internal mixing of questions (Voborník, 2015, 2016), a high-quality tool for self-learning and testing arises.

Although this model is only applicable to the specific type of tests (repeated testing) and only for some learning subjects (uncreative), it can be an inspiration not only for the implementation of future testing applications, but also for the further development of the theory of choice function, either in this or an entirely different science branch.

## ACKNOWLEDGEMENT

This paper has been supported by Specific research project of University of Hradec Kralove, Faculty of Science in 2016.

Author thanks to Josef Lejp for correction of English translation.

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# Teaching Database Systems and Technologies in Economy and Managerial Study Fields

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## Abstract

*The paper presents a part of the results of a research, which goal was to analyse current state and perspectives of informatics education on the tertiary level of education in selected economy and managerial study fields. Purpose of the research was to support curricula modernization and innovation in the relevant study programmes and to bring the content of this study closer to the current demands and needs of practice and labour market as to the knowledge and skills of the graduates. An original feature of the research has been the fact that it was based on students' points of view. Necessary research data were collected through a questionnaire survey which respondents were students of the concerned study programmes in the Slovak and Czech Republic. Most of the questionnaire items was focused on finding out how the students of the economy and managerial study programmes evaluate informatics education incorporated in their pre-graduate education (its curricula and to them related teaching processes) from the point of view of its relevance and importance to their study and career profilization. In the paper there are presented findings regarding the issues of teaching database systems and technologies within informatics education incorporated into the concerned economy and managerial study programmes taking into consideration these students' study and career profilization.*

## Keywords

*Computer and Informatics Science Education. Tertiary Education. Economy and Managerial Study Programmes. Curricula Innovation. Database Systems. Database Technologies.*

## INTRODUCTION

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Nowadays in Slovakia informatics is integrated in different forms in the study programmes almost of all study fields carried out at the tertiary level of education. An important reason, why informatics topics are included into the study programmes of the study fields economy and management on the tertiary level of education (ISCED 6, ISCED 7), is a need to develop students' computer literacy in general (<http://www.akredkom.sk/index.pl?tmpl=odborny>) and enhance mainly those their informatics competencies which have a broad transfer from the point of practice and labour market view (<http://www.alianciapas.sk>). Although acquirement and development of informatics competencies support one's general professional adaptability and his/her possibilities to employ on the labour market at the same time it also enhances one's adaptability in personal out-of-service life (Skalka, Drlík and Švec, 2012; Pešaković, Flogie and Aberšek, 2014).

Proclaimed overall unsatisfactory level of informatics education within the economy and managerial study programmes considerably relates to the insufficient attention paid to the fitting of issues of teaching database, information systems and internet technologies into the study programme curricula. Partially it is also a consequence of a low lesson allocation devoted to subjects taught within the informatics education in the concerned study programmes (Carlsson, Hedman and Steen, 2010; Lareki, Morentin and Amenabar, 2010). Goal-directed development of students' knowledge and skills in the area of database systems and database technologies (systematic creation of databases, work with data in different basis) supports also one's logical and analytical thinking, invention and creativity. Last but not least database systems and technologies teaching offers broad possibilities to apply already gained knowledge and skills at solving tasks and problems relevant to the particular study profilizations (Helfert and Duncan, 2006).

## PURPOSE OF THE RESEARCH

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Particular experiences, approaches and results, related to education curricula in the informatics (computer and informatics science) area in frame of economy and managerial study fields at tertiary levels of education (ISCED 6, ISCED 7) in developed West European countries, USA as well as in countries similar to the our one, can be found in different scientific and professional publications (Fan, Yang and Zhang, 2015; Tumbas, Sedlak and Matkovic, 2009; Ekstrom and Renshaw, 2003; Springsteel, Robbert and Ricardo, 2000; Robbert, *et al.*, 2000). The authors share in them opinion that readiness of the graduates of the economy and managerial faculties to be successful on the labour market depends, besides their economy and managerial erudition, on having appropriate knowledge and skills in the use of digital technologies and application software products at economy and social analyses and modelling and at processing statistical and prognostic analyses for different national and international economy branches.

In the view of the business subject these competencies are many times the key factor at recruitment of new employees – novice graduates of the concerned study branches, as the graduates skilled in the work with database technologies and data mining in quantitative statistical method applications are usually very successful and productive in the work environment (Jakuš and Páleníková, 2009).

As it results from different researches, currently informatics education carried out most of the tertiary economy and managerial study programmes in Slovakia do not reflect up-to-date needs of practice and requirements, which employers have towards the graduates' competencies. A way, how to eliminate the proclaimed dissatisfaction with informatics education offered by the higher education institutions to their students within the economy and managerial study programmes, is to innovate and modernize the relevant curricula and to bring their content closer to the demands and needs of the labour market. But this has to be done on a reasonable platform, not in an intuitive way. To create such a platform for a possible innovation of the informatics education leading to a higher professional competency of the graduates of the economy and managerial study fields there was initiated a research which aim was to analyse the current state of informatics education within the relevant study programmes.

## **METHODOLOGY OF THE RESEARCH**

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The carried out research analysed the current state of the informatics education in the selected economy and managerial study programmes in order to create a reasonable platform for an innovation of this education, which would lead to a higher professional competency of the graduates on the labour market.

Considering the relationship between the systems of education in the Slovak and Czech Republic (their common development), the Czech Republic was chosen as a comparative country, the situation in Slovakia was compared with. In Slovakia the research sample consisted of students of the Faculty of Economics and Management (FEM), Slovak University of Agriculture (SUA) in Nitra, enrolled in one of the following study programmes: Business Management (BMA), Quantitative Methods in Economics (QME), Accounting (AC), Agrarian Trade and Marketing (ATM) or Business Economics (BEC), and students of the Faculty of European Studies and Regional Development (FESRD), Slovak University of Agriculture (SUA) in Nitra, enrolled in the study programme European Development Programmes (EDP). Due to our limited possibilities the research sample in the Czech Republic consisted only of the students attending the Faculty of Business and Economics (FBE), Mendel University (MU) in Brno, enrolled in study programmes Economic Policy and Administration (EPA) and Accounting and Taxes (ACT). All these faculties offer education in nearly identical study programmes of economy and managerial study specializations.

Composition of the research sample in dependence on the factors COUNTRY, GENDER and FIELD OF STUDY (study profilization) is presented in Table 1. Herein it is necessary to notice that COUNTRY means the country in which the respondents undergo their higher education studies and not the respondents' nationality.

Mapping and analysis of the current state of informatics education in the concerned study programmes was based on the screening of the students' opinions by means of a questionnaire survey (Záhorec, Hašková and Munk, 2014). The necessary research data were collected through a questionnaire in frame of which the respondents expressed their opinions and assessments of different actually taught or potentially innovated topics related to database systems and database technologies issues.



Table 1: Composition of the research sample according the respondents characteristics.

	Factor	N
COUNTRY	Slovakia (SR)	493
	Czech Republic (CZ)	42
GENDER	Female (F)	373
	Male (M)	162
FIELD OF STUDY	Business economics (BEC)	319
	Agrarian trade and marketing (ATM)	62
	Quantitative methods in economics (QME)	28
	Accounting (AC)	37
	Business management (BMA)	20
	European development programs (EDP)	27
	Accounting and Taxes (ACT)	18
	Economic policy and administration (EPA)	24
Total		535

In the screening the students expressed their opinions and requirements or needs to insertion different relevant topics into the curricula of their study programmes from the point of view of their study specialization. The screening was based on the use of a questionnaire consisted of 104 items which were structured in six areas (questionnaire parts A – F):

- Part A: *Introduction* (7 items)  
Identification of the respondent's gender, age, study specialization
- Part B: *What I want to learn* (26 items)  
Identification of the informatics topics/subjects which the students want to learn from those included in the actual curriculum of their study programmes, estimation of the level of attractiveness of these subjects for students (how interesting they are for students in the context of their further career specialization)
- Part C: *My future profession* (24 items)  
Estimation of the level to which some given factors are important for students in their decisions made at their future job selection
- Part D: *What I would like to learn* (22 items)  
Identification of the informatics topics/subjects which the students would like to learn and which are not included in the actual curriculum of their study programmes, estimation of the level of attractiveness of these subjects for students (how interesting they are for students in the context of their further career specialization)
- Part E: *My education in the field of informatics* (18 items)  
Assessment of some statements regarding the informatics education the students have already passed during their higher education study (estimation of

the measure to which the students agree or do not agree with the given statements)

- Part F: *My professional competencies in the context of the study specialization* (7 items)

Screening of the students' opinions on the development of their study specialization: how they assess their professional competency and how they assess their possibilities to employ on the labour market in the context of their study specialization

In the parts B – E the respondents expressed their opinions and assessments to the particular questionnaire items through five point Likert scale, i.e. through assessments from 1 to 5 points with a mean value to express neutral, emotionally indifferent evaluative answer. A higher level of the negative assessment or disagreement was expressed by a lower point value, markedly negative assessment or a total disagreement was expressed by the point value 1. A higher level of the positive assessment or agreement was expressed by a higher point value, the maximum positive assessment or a total agreement was expressed by the point value 5. At each respondent his/her responses to the particular items were recorded, i.e. one recorded the scale values by which the respondent assessed the particular informatics topic areas from the point of view of their interest and attractiveness for his/her study specialization, and the scale values corresponding to the degree of the respondent's agreement or disagreement with the particular given statements.

In the questionnaire part named *My professional competencies* in the context of the study specialization the respondents chose out of seven alternative answers the one which they identified mostly with, or which represented their viewpoint mostly.

This paper presents some results of the research done with the above mentioned final research sample (Table 1), regarding teaching topics related to issues of database systems and database technologies.

## RESULTS, MAIN FINDINGS AND THEIR DISCUSSION

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Reliability of the questionnaire was calculated through the Cronbach alpha coefficient. The Cronbach alpha value stated for the questionnaire part B – *What I want to learn* was  $\alpha_B = 0.9570$ , what indicates a high level of the internal consistency of the used measuring tool.

Results of the assessments of the subjects currently incorporated into the concerned study programmes from the students' point of view are summarized in the graph in Figure 1. The box plot presents mean, standard error of the estimated mean and standard deviation of the assessments at the particular items.

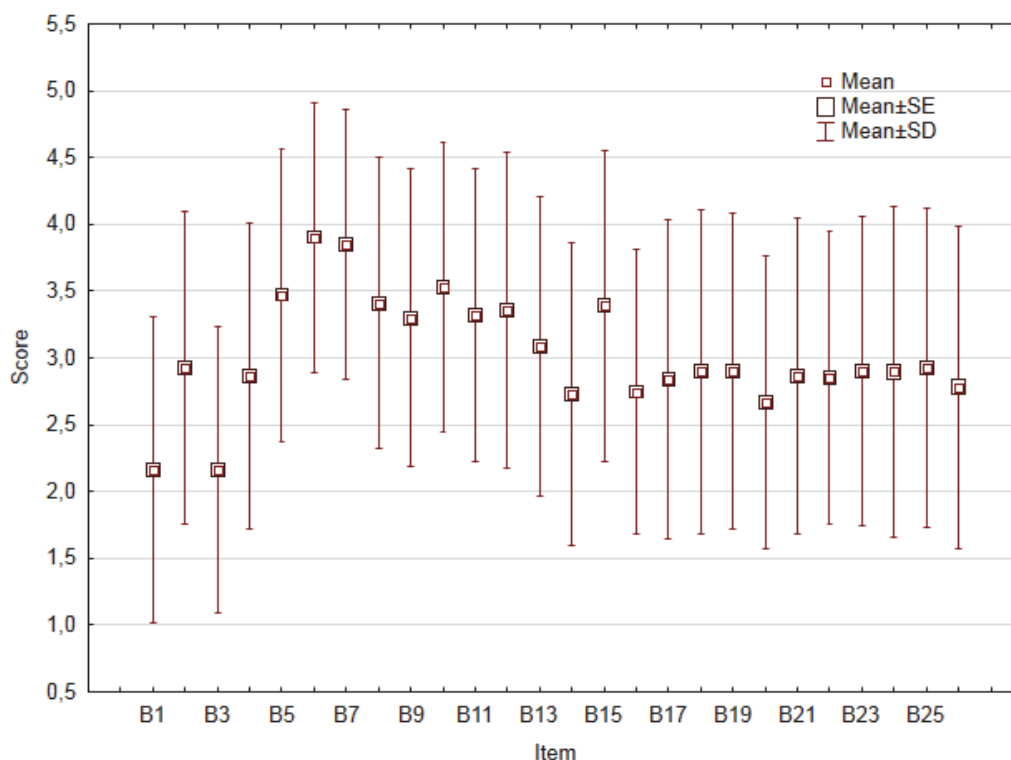


Figure 1: Box plot – differences in ratings of the items from the questionnaire part B *What I want to learn*.

*Explanatory notes: B1 – Algorithmization of mathematical problems solving; B2 – Computer hardware; B3 – Number systems, transfer algorithms of numbers between systems; B4 – Administration and orientation in structure of objects and data stored in Windows; B5 – Use of standard tools and Windows applications; B6 – Use of tools and advanced techniques of work with MS PowerPoint to create interactive presentations; B7 – Creating and formatting of structured documents using MS Word tools; B8 – Data entry through data form, formatting, data editing and data back-up; B9 – Creating documents for mail merge; B10 – Possibilities of conditional cell formatting in MS Excel; B11 – Filtering large tables, defining filter criteria for the values of different formats; B12 – Use of functions; B13 – Work with large tables using data tools; B14 – Creation of own expressions by combining different functions; B15 – Graphical interpretation of data (creation and changing chart attributes); B16 – Using the tools for analytical output creation; B17 – Numerical and graphical analysis of data through the pivot table and pivot chart; B18 – Utilization of macros to automate repetitive operations in MS Excel; B19 – Definition of the table design in the MS Access database application; B20 – Defining relationship between database tables; B21 – Work with forms in MS Access database application; B22 – Selection of required data using select query; B23 – Creation of own calculations and use of functions in select query; B24 – Using aggregate functions in queries for statistical, financial and economic data analysis; B25 – Creation of simple reports in MS Access; B26 – Dynamic interconnection of data between MS Access and external applications*

Issues of teaching database systems and database technologies instruction and issues of incorporating these topics into the informatics education carried out within the

observed study programmes were investigated in questionnaire items B19 – B22, B24, B26. An overview of descriptive statistics to these questionnaire items is presented in Table. 2.

Table 2: Descriptive statistics for selected items from the part B *What I want to learn*.

B19 / B20 Level of Factor	<b>B19</b>			95% Confidence Interval for the Mean		<b>B20</b>			95% Confidence Interval for the Mean	
				-95%	+95%				-95%	+95%
Total	2.90	1.18	0.05	2.80	3.00	2.67	1.10	0.05	2.57	2.76
SR	2.90	1.16	0.05	2.80	3.01	2.65	1.07	0.05	2.55	2.74
CZ	2.86	1.39	0.21	2.42	3.29	2.86	1.42	0.22	2.41	3.30
F	2.96	1.19	0.06	2.84	3.08	2.70	1.11	0.06	2.59	2.82
M	2.77	1.15	0.09	2.59	2.95	2.58	1.06	0.08	2.42	2.74
BEC	2.94	1.13	0.06	2.81	3.06	2.68	1.04	0.06	2.57	2.80
ATM	2.89	1.20	0.15	2.58	3.19	2.69	1.10	0.14	2.42	2.97
QME	3.61	1.03	0.19	3.21	4.01	3.21	1.20	0.23	2.75	3.68
AC	2.84	1.07	0.18	2.48	3.19	2.70	0.94	0.15	2.39	3.02
BMA	2.55	1.28	0.29	1.95	3.15	2.20	0.83	0.19	1.81	2.59
EDP	2.19	1.21	0.23	1.71	2.66	1.85	0.99	0.19	1.46	2.24
ACT	2.83	1.58	0.37	2.05	3.62	2.78	1.48	0.35	2.04	3.51
EPA	2.88	1.26	0.26	2.34	3.41	2.92	1.41	0.29	2.32	3.51

B21 / B22 Level of Factor	<b>B21</b>			95% Confidence Interval for the Mean		<b>B22</b>			95% Confidence Interval for the Mean	
				-95%	+95%				-95%	+95%
Total	2.87	1.18	0.05	2.77	2.97	2.85	1.10	0.05	2.76	2.94
SR	2.87	1.16	0.05	2.77	2.98	2.85	1.09	0.05	2.76	2.95
CZ	2.83	1.40	0.22	2.40	3.27	2.81	1.25	0.19	2.42	3.20
F	2.91	1.19	0.06	2.79	3.03	2.86	1.07	0.06	2.75	2.97
M	2.78	1.17	0.09	2.60	2.97	2.83	1.16	0.09	2.65	3.01
BEC	2.91	1.13	0.06	2.78	3.03	2.92	1.10	0.06	2.80	3.05
ATM	2.77	1.18	0.15	2.47	3.07	2.65	1.04	0.13	2.38	2.91
QME	3.75	0.97	0.18	3.38	4.12	3.39	0.92	0.17	3.04	3.75
AC	2.84	1.21	0.20	2.43	3.24	2.62	1.11	0.18	2.25	2.99
BMA	2.65	1.18	0.26	2.10	3.20	2.85	0.75	0.17	2.50	3.20
EDP	2.00	1.07	0.21	1.58	2.42	2.26	1.06	0.20	1.84	2.68
ACT	2.83	1.58	0.37	2.05	3.62	2.78	1.31	0.31	2.13	3.43
EPA	2.83	1.27	0.26	2.30	3.37	2.83	1.24	0.25	2.31	3.36

B24 / B26 Level of Factor	<b>B24</b>			95% Confidence Interval for the Mean		<b>B26</b>			95% Confidence Interval for the Mean	
				-95%	+95%				-95%	+95%
Total	2.90	1.24	0.05	2.79	3.00	2.78	1.20	0.05	2.68	2.89
SR	2.88	1.23	0.06	2.77	2.98	2.80	1.19	0.05	2.70	2.91
CZ	3.14	1.34	0.21	2.73	3.56	2.55	1.35	0.21	2.13	2.97
F	2.86	1.27	0.07	2.73	2.99	2.77	1.19	0.06	2.65	2.89
M	2.98	1.15	0.09	2.80	3.15	2.81	1.25	0.10	2.61	3.00
BEC	2.97	1.19	0.07	2.83	3.10	2.89	1.13	0.06	2.77	3.02
ATM	2.56	1.20	0.15	2.26	2.87	2.65	1.20	0.15	2.34	2.95
QME	3.75	0.80	0.15	3.44	4.06	3.39	1.20	0.23	2.93	3.86
AC	2.76	1.21	0.20	2.35	3.16	2.59	1.30	0.21	2.16	3.03

BMA	2.60	1.14	0.26	2.07	3.13	2.60	1.23	0.28	2.02	3.18
EDP	2.00	1.44	0.28	1.43	2.57	1.96	1.19	0.23	1.49	2.43
ACT	3.06	1.30	0.31	2.41	3.70	2.44	1.42	0.34	1.74	3.15
EPA	3.21	1.38	0.28	2.62	3.79	2.63	1.31	0.27	2.07	3.18

Dependence of the respondent's answers on the factors COUNTRY, GENDER and FIELD OF STUDY was tested for all items B1 – B26. It means that validity of the three null hypotheses, from which each one represents de facto 26 partial null hypotheses, was verified:

H0: Answers to the items B1 – B26 in the area *What I want to learn* do not depend on the factor COUNTRY / GENDER / FIELD OF STUDY (respectively).

The dependence was tested by the means of parametric tests. In case of the items B19, B20, B21, B22, B24 and B26 the dependence was proved only in relation to the factor FIELD OF STUDY.

As it follows from the results of the analysis of variance summarised in Table 3, at testing the dependence of the respondents' responses on the factor FIELD OF STUDY the p value was lower than 0.05, based on what the null hypothesis was rejected and it was stated that the respondent study specialization has a significant influence on how they evaluate the tested items B19, B20, B21, B22, B24 and B26.

Table 3: Analysis of variance for the factor FIELD OF STUDY.

Item	B19				B20			
	SS	MS	F	p	SS	MS	F	p
Intercept	1937.457	1937.457	1428.406	0.000000	1662.103	1662.103	1434.634	0.000000
St. Field	30.939	4.420	3.259	<b>0.002136</b>	32.551	4.650	4.014	<b>0.000271</b>
Error	714.810	1.356			610.559	1.159		
Total	745.750				643.110			

Item	B21				B22			
	SS	MS	F	p	SS	MS	F	p
Intercept	1915.640	1915.640	1436.707	0.000000	1868.455	1868.455	1588.318	0.000000
St. Field	44.163	6.309	4.732	<b>0.000036</b>	24.089	3.441	2.925	<b>0.005186</b>
Error	702.678	1.333			619.949	1.176		
Total	746.841				644.037			

Item	B24				B26			
	SS	MS	F	p	SS	MS	F	p
Intercept	1969.625	1969.625	1366.452	0.000000	1680.836	1680.836	1202.254	0.000000
St. Field	55.720	7.960	5.522	<b>0.000004</b>	38.065	5.438	3.890	<b>0.000382</b>
Error	759.626	1.441			736.783	1.398		
Total	815.346				774.849			

After the approval of the statistically significant differences among the respondents' answers in dependence on the factor FIELD OF STUDY, there was a search for the study groups between which in the context of their various study profilization this occurred. In

dependence on the factor FIELD OF STUDY the average scores of the responses to the items B19, B20, B21, B22, B24 and B26 took a value from 1.85 (*rather uninteresting*) even to 3.75 (*rather interesting*) from the maximum scale value. The lowest mean of the response values, among all the observed items focused on database systems and database technologies issues, was recorded at the group of EDP (European Development Programmes) study programme. This study programme students evaluated the given learning topics rather in a negative way. The highest average score, in case of the respondents differentiation according to the factor FIELD OF STUDY, was recorded at the group of QME (Quantitative Methods in Economics) study programme students at two items, in particular B21 (*work with forms in MS Access database application*) and B24 (*using aggregate functions in queries for statistical, financial and economic data analysis*), equally 3.75 (*rather interesting*).

Following the average scores of the responses to the items B19, B20, B21, B22, B24 and B26 in the context of the respondent differentiation according to the factor FIELD OF STUDY there was no marked favour (popularity) of the learning topics related to database systems and database technologies, in the observed study specializations. The values of the average score were mostly at the scale level 3 (*neither interesting nor uninteresting*). Deviation from this neutral response was noticeable in the group of BMA study programme students at the assessment of the interest/attractiveness of the topic defining relationship between database tables (B20) and in the group of EDP study programme students at the assessment of all six items related to the database systems and database technologies issues. In these cases the average values of the responses were about the scale level 2 (*rather uninteresting*).

Testing the significance of the differences among the means of the items B19, B20, B21, B22, B24 and B26, only the difference between the groups of QME and EDP study programme students was proved. This result can have a bearing on the fact that students of the study programme QME (Quantitative Methods in Economics), following the structure of the learning courses (subjects) included in their study programme, are led to a more intense use of the software products and engineering and economical ICT applications in comparison to the EDP (European Development Programmes) study programme students. The structure of compulsory, compulsory optional and optional subjects from the informatics area offered within the particular study programmes is almost identical, with the exception of the subject structure of the QME study programme, but in their topical curricula none of the subjects goes deeper into the concerned issues.

The results of the variance analysis proved the statistical significance of the differences among the responses of the respondent groups – students of the EDP and EPA study programmes, in particular at the item B20 (*defining relationship between database tables*), and the respondent groups – students of the ATM and QME study programmes at the item B21 (*work with forms in MS Access database application*). In case of the item B24 assessment (*using aggregate functions in queries for statistical, financial and economic data analysis*). Similar situation was at the items B20 and B21, at the respondents with study specialization ATM and QME, or EDP and EPA.

## CONCLUSION

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With regard to the possibilities of the economy and managerial study programme graduates to employ themselves in the labour market in the context of its current requirements on their professional competencies, it is indisputable that the issues of the database systems and database technologies should be included in the study programmes of their pre-graduate training. A question is specification of the learning topics related to the database systems and database technologies issues, which should be accentuated and which should be stated as inessential or supplementary for the profilization of the concerned study programme graduates. As to the innovation of the database systems and database technologies instruction, for creation of its conception we consider the following findings of our research to be the most important:

- From the point of their professional profilization view the respondents stated the topics use of tools and advanced techniques of work with MS PowerPoint to create interactive presentations, use of tools and advanced techniques of work with MS PowerPoint to create interactive presentations and possibilities of conditional cell formatting in MS Excel (questionnaire part B: What I want to learn) as the most significant.
- From the alternative topics from the point of view of their professional profilization the respondents stated the topics programming and web site design, programming of the web applications (chat, discussion forums, e-business) and harmful software (questionnaire part D) as the most significant.  
However here, in the context of the presented findings, it can be polemized whether it is a consequence of the specific requirements of the professional profilization or rather a consequence of the need to develop the common key competencies of each information society member (Hrmo and Turek, 2003; Hašková, 2004; Šimonová, 2009).
- As the least significant areas for the professional development of the respondents, on the basis of their responses, out of the given topics (questionnaire part B) the algorithmization of mathematical problems solving and number systems, transfer algorithms of numbers between systems were identified, what opens a space for prospective curricula innovations in favour of database systems and database technologies instruction.
- On the other hand, out of the given alternative topics to be taught (questionnaire part D) the lowest interest was identified just at the topics work with databases and databases technologies and data processing in database systems using the SQL and VBA language. But this can be partially a result of a low familiarity of the respondents with the content of these topics (programming tools) and their applicability in practice (general unfamiliarity with the possibilities and ways of their practical utilization).
- In the context of the aforementioned point it should be noted that just in case of the instruction of the database systems and database technologies issues there was proved a significant dependence of the respondents' responses on their study profilization (dependence on the factor FIELD OF STUDY), independently on the fact whether the respondents were boys or girls or

students in the Slovak or Czech Republic (independence on the factors GENDER and COUNTRY).

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Section:  
**Intelligent Computing**

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# Application of POS Tagging in Machine Translation Evaluation

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## Abstract

*The aim of the paper is to present a process of natural language processing in its full extent as well as in machine translation from English language into Slovak as a representative of inflectional language. We aim at the data preparation phase for automatic evaluation of machine translation through POS tagging. The preparation phase for MT evaluation consists of several steps, but only the first step - creation of dataset- parallel corpus is deeply described. We focus on the source text collection of various styles and genres-dataset creation and machine translation collection. Two machine translation systems are used- web SMT Google translator API and MT@EC. As a morphology analyzing tool- TreeTagger is used. The process of dataset creation, which covers not only parallel corpora creation, but also creation of errors' database of Slovak words with morphological annotation, is analyzed. The main contribution consists of a novel approach to research of MT evaluation given by the POS tagging (machine learning methods), to identify differences between MT output and post-edited machine translation output. The ground essential of the research is machine translation errors analysis, their identification and classification, from English language into Slovak.*

## Keywords

*Natural language processing. Evaluation. Machine Translation quality. Sentence alignment. Tokenization. POS tagging.*

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## INTRODUCTION

Nowadays Machine translation (MT) and the quality of machine translation (MT output or MT system itself) became a subject of research not only in the academic sphere, but also in commercial. Machine Translation offers low costs and high speed of translation comparing to human translation. Despite that, the quality of Machine Translation is still far behind human translation. Many approaches how to measure a quality of machine translation were proposed, but the experiments were mainly conducted between English

language and other major languages (Spanish, German, French), not yet among the inflectional languages rich in morphology and syntax, as Slovak language is. MT evaluation can be realized in two directions – manual (ME) and automatic (AE). Manual evaluation is regarded as the most reliable, especially the errors analysis, but it is time and labor consuming and not re-usable compare to automatic evaluation, which is fast, cheap and re-usable. In an effort to make evaluation more effective and objective without the intervention of human evaluators (ME) or similarity between MT output and reference-human translation (AE), automatic machine learning techniques and techniques from natural language processing have more been applied to MT evaluation. MT evaluation is a highly challenging task not only for developers, who design new systems or improve the potential performance of the existing MT systems based on the MT evaluation (translation quality), but also for linguists, who want to proceed natural language in whole its extent. In this paper, we examine MT quality in relation to Slovak language as an inflectional type of language with a huge number of morphological forms (including grammatical polysemy a homonymy), which often cause inadequate semantical and syntactical analysis of machine translation. Issues of machine translation are more topical since there are not many studies concerning the evaluation of machine translation.

The paper describes a preparation phase for MT evaluation from English into Slovak language over the written texts of scientific, administrative and journalistic domains. In our research, the preparation phase for MT evaluation consists of several steps, but only the first step - creation of dataset- parallel corpus will be more deeply described in this paper. As MT systems, Google translator and MT@EC were used. They were chosen for several reasons; Google translator is a free online statistical MT, comprising a huge number of parallel and comparable texts (including Slovak language). MT@EC is a statistical machine translation system based on corpora (reports from European Parliament and Commissions), designed by DGT EC for translating administrative texts, also covering translation from/to Slovak language.

The rest of the paper is structured as follows. The next section describes the actual state of the act of research and introduces the main topics of Statistical Machine Translation. The third section summarizes the preparation of dataset- parallel corpora and techniques during the process. The last section provides the conclusion.

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## **RELATED WORK**

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Statistical machine translation (SMT) is an approach to Machine Translation that is characterized by the use of machine learning methods. SMT treats translation as machine learning problem (Lopez, 2008). The basis of SMT is to create a system that can automatically discover translation rules of the large bilingual corpus, merge starting sentences of text (input data) with target sentences (output data) and “be taught” by the results of the statistical analysis of relevant data (Koehn, 2010).

Acquisition of a parallel corpus for the use in a statistical machine translation system typically takes five steps (Koehn, 2005):

- obtain the raw data;
- extract and map parallel chunks of text (document alignment);
- break the text into sentences (sentence splitting);

- prepare the corpus for SMT systems (normalization, tokenization);
- map sentences in one language sentences in the other language (sentence alignment).

Raw data can be obtained for example from literature or web portals (such as European Parliament) (Koehn, 2005). Extraction of relevant text from HTML is troublesome and requires constant adaptation. Parallel corpora will be created using the machine translation tools involving English and German texts.

Sentence splitting involves the problem of the ambiguity of the period “.” as either end of sentence marker, or as marker of an abbreviation (Koehn, 2005). For resolving this problem, we can look for the word following the period that could indicate the abbreviation and not the end of sentence. Various authors contributed to solving this problem using different machine learning methods (Collados, 2013; Doi and Sumita, 2003; Štajner et al., 2013; Yang et al., 2015).

Tokenization in the field of Natural Language Processing can be defined as the task of splitting a stream of characters into words. Tokenization can be done before or after the sentence alignment, the result should be the same. For our research, we categorized words after the sentence alignment phase. With the help of TreeTagger tool, it is possible to annotate text with part-of-speech (POS) (Benko, 2013) and lemma information (“TreeTagger - a language independent part-of-speech tagger,” n.d.). The TreeTagger has been successfully used to tag many languages including Slovak language. The tagger was developed by Helmut Schmid and is described in more detail in (Schmid, 1999, 1994). With the help of the tagger it is possible to output the morphological annotation of the examined texts. Morphological annotation is a fundamental and common linguistic information that can be found in corpus. It comprises the grammatical and morphological features of word in context (Ľ. Štúr Institute of Linguistics, n.d.). The annotation for Slovak language is described in detail in (“Morfologická anotácia textov Slovenského národného korpusu,” n.d.).

Sentence alignment require specialized tools. Authors in (Jassem and Lipski, 2008) divided the alignment process into seven independent phases (parsing, segmenting, cleaning, aligning, segmenting, merging and formatting). According to specific needs, some of the phases of the process may not occur or may occur more than once. After parsing the input documents in order to obtain the common data type, follows the segmentation of source and target texts. Cleaning phase clean the segments from unwanted characters (for example whitespaces). The most important phase of the process is aligning phase. Corresponding segments are aligned separately in each mapping. The alignment can be done using different algorithms that will be described in the next section. Selecting phase selects the best mapping according to user criteria. Merging phase merges all source and target segments into one source and one target segment but if the output is not allowed other mapping than one to one, then this phase is not executed. The last phase formats the alignment into the desired format. Nowadays exist many tools for working with various inputs that can apply the whole process of sentence or word alignment and export them in a needed output format.

## DATASET

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The most important phase of MT evaluation using the POS tagging is a data preparation (Munk et al., 2010; Munk and Drlik, 2011). In our case, the data preparation consists of dataset creation. Dataset covers texts of given styles, machine translations (MT) and post-edited machine translations (PEMT) as well as their POS tagging. In different word, we will create parallel corpora (EN-SK) of English texts, Slovak translations using MT system, post-edited Slovak translations and their morphological annotations. As mentioned in the previous section, we undertook the five steps (Koehn, 2005) to create the parallel corpora.

The examined texts consist of different styles (scientific, administrative and journalistic) to cover more deeply the diversity of Slovak language. After obtaining the raw texts, we removed all formatting in the obtained documents and translated the texts using the machine translation tools, both based on SMT ("Google Translate API - Fast Dynamic Localization — Google Cloud Platform," n.d. and "MT@EC" offered by the European Commission). The formatting was removed because it can sometimes interfere with the translation tool and in the later phase with the alignment tools and tagging tools. The problem can be that the translation tool inserts end of the line into the translation, where it should not be. This could create errors during the phase of sentence alignment so we rather removed all document formatting.

Next, we focused on the phase of sentence alignment and left tokenization for the end. Automatic sentence alignment was carried out using the algorithm and software hunalign (Varga et al., 2005). There are three main approaches to the problem of corpus alignment at the sentence level: length-based (Brown et al., 1991; Tóth et al., 2008), dictionary (translation) based (Melamed, 2004, 2000; Moore, 2005; Yu et al., 2010) and partial similarity-based (Hirao et al., 2004). Neural networks can also be used for sentence alignment as suggest authors in (Sutskever et al., 2014) and are suitable for high-speed classification (Škropil and Šťastný, 2009). Hunalign is an algorithm based on dictionary and length-based methods, which successfully amalgamates these two (Varga et al., 2005). For performance reasons the algorithm does not take into account the possibility of more than two sentences matching one sentence. The aligner was tested also for special situations where the source sentence was translated into two separate sentences, which the tool recognized. After the processing we produced an output file in a xls file format (Table 1) containing rows with each sentence in source (English) and target (Slovak) language and information about files they were taken from. While we cannot publish most of texts in either language, the aligned sentence pairs will be published in random order. This makes it hard to reconstruct the original texts but also loses the context in which the sentences were arranged.

Table 1: Output of the aligned sentences.

Source language	Target language	Files
"Oh, I don't know."	"No, ja neviem."	TextEN-TextSK
A second cry arose, piercing the silence with needlelike shrillness.	Druhý výkrik vznikol, piercing ticho jehlovitým prenikavosťou.	TextEN-TextSK
One Ear didn't get no fish.	Jedno ucho nedostal žiadne ryby.	TextEN-TextSK
John did not reply, but munched on in silence, until, the meal finished, he	John neodpovedal, ale žuval mlčky, až sa jedlo skončil, prikrývali ju s	TextEN-TextSK

topped it with a final cup of coffee.	konečnou šálkou kávy.	
He sucked meditatively at his pipe for some time before he went on.	Prudko zadumane na svojej fajky na nejakú dobu, než pokračoval.	TextEN-TextSK
...	...	...

The next phase was focused on tokenization of the translated texts. For this phase we used the algorithm and tool TreeTagger. Input of TreeTagger contains the Slovak translated texts. Words are extracted from the sentences and annotated according the morphological annotation tags. Output of TreeTagger contains three columns containing the word (token), tag and a lemma, where tag and lemma could be understood as attributes of the token. A lemma is a dictionary entry of a token. Tags contain information about the examined words (tagset) that consists of a number of alphanumerical symbols, each representing a characteristic of the token. The first character determines the word class of the token: noun, adjective, pronoun, numeral, verb, participle, adverb, preposition, conjunction, particle, interjection, reflexive morpheme, conditional morpheme, abbreviation (symbol), punctuation, number or incorrect spelling. Next, it is followed by symbols of grammatical categories (obligatory) or symbols for specific classes.

Table 2: Output of the tagger TreeTagger.

Word (token)	Tag	Lemma
Druhý	NAis1	druhý
výkrik	SSis1	výkrik
vznikol	VLdsci+	vzniknúť
,	Z	,
piercing	SSis1	<unknown>
ticho	Dx	ticho
jehlovitým	AAfs4x	<unknown>
prenikavosť	SSfs4	prenikavosť
.	SENT	.

As can be seen in Table 2, the column tag consists of symbols with exact meaning. This table contains the tokenization of the second sentence of Table 1 for the target language. For example we can see that the English word “cry” was translated by the translation tool as “výkrik” and the tagger categorized the word with the symbols SSis1. This means, that the word is a noun (S), with a substantive paradigm (S), masculine inanimate genus (i), singular (s), nominative (1). Table 2 contains also a foreign word “piercing” that was categorized correctly but the tagger does not know the lemma for this word and marked it as <unknown>. The tagset and morphological annotation for Slovak language is described in Table 3, which contains all classes and their respective categories with corresponding symbols. In detail, the authors deal with the issue in (Garabík et al., 2004).

Table 3: POS tagging for Slovak morphological annotation.

Classes	Categories
Noun	5 (Class (S), Paradigm (S, A, F, U), Gender (m, l, f, n), Number (s, p), Case (1-7))
Adjective	6 (Class (A), Paradigm (A, F, U), Gender congruence (m, l, f, n), Number congruence (s, p), Case congruence (1-7), Degree (x, y, z))
Pronoun	6 (Class (P), Paradigm (S, A, P, F, U, D), Gender (m, i, f, n, h), Number (s, p), Case (1-7), agglutinance (g))



Numeral	5 (Class (N), Paradigm (S, A, N, F, U, D), Gender (m, i, f, n), Number (s, p), Case (1-7))
Verb	7 (Class (V), Verbial form (I, K, M, H, L, B), vid (d, e, j), Number (s, p), Person (a, b, c), Gender congruence (m, i, f, n), Negation (-, +))
Participle	6 (Class (G), category (k, t), Gender congruence (m, i, f, n), Number congruence (s, p), Case congruence (1-7), Degree (x, y, z))
Adverb	2 (Class (D), Degree (x, y, z))
Preposition	3 (Class (E), Form (v, u), Case congruence (2, 3, 4, 6, 7))
Particle	2 (Class (T), Conditional (Y))
Conjunction	2 (Class (O), Conditional (Y))
Interjection	1 (Class (J))
Reflexive morpheme	1 (Class (R))
Conditional morpheme	1 (Class (Y))
Abbreviation, symbol	1 (Class (W))
Punctuation	1 (Class (Z))
Undefinable part of speech	1 (Class (Q))
Non verbal element	1 (Class (#))
Foreign language citation	1 (Class (%))
Number	1 (Class (0))
Proper name	1 (Last position (:r))
Incorrect spelling	1 (Last position (:q))

After the sentence alignment, the aligned sentences will be imported to a database for post-editing. This phase will be done manually, where translators will use a prepared web interface to correct the errors in translation that were created during the machine translation. After the post-editing the machine translated sentences and post-edited sentences will also be tokenized. The output of the tagger will be manually verified by linguists.

## CONCLUSION AND FUTURE WORK

We described another approach how to evaluate the performance of machine translation system through the machine learning technique. In our paper, we focused on a process of dataset creation, which belongs to the most important phase during the evaluation. As it was mentioned before, the manual evaluation is regarded as the most reliable, but time consuming and very subjective. Using the tools for natural language processing (previous section), we can create a parallel corpus, e.g. EN-SK or MT-PEMT, which can be analyzed and evaluated in terms of the quality of MT output. There are many options how to complete each phase of parallel corpora creation. Sentence alignment, to match up sentence pairs, in our case, the Hunalign was used. The output of the aligner was satisfactory and it was integrated into a web interface for post-editing. Tokenization of translated and post-edited sentences was introduced using the tool TreeTagger. The output of each of the tools will be implemented into a MySQL database. Further analysis and interaction with the translated texts will be done with the use of a website interface based on PHP language.

This paper described the process of creating parallel corpora. It deals with sentence alignment and tokenization of words translated using the machine translation. Word

tagging and explanation of tagset for Slovak morphological annotation was described. For our purpose, two web MT services, Google translator API and MC@EC, both based on SMT were used. We chose translation direction from English language into Slovak. English as an analytical language has a strict word order, on the contrary Slovak as an inflective language has a loose word order, which is not possible in English sentence structure.

Therefore, the intention of the research, which is presented here only in its data preparation phase is machine translation automatic error analysis, namely automatic errors identification and classification, from English into Slovak language over three different domains. The future work will be focused on creating an algorithm for identifying morphological errors in the translation using machine translation tools. The algorithm will also classify the found errors and evaluate the error rate of machine translation. Based on the result of tokenization will be created a tool for automatic identification and classification of errors that occurred during the machine translation.

Above that, MT in Slovak language has not been investigated yet, which makes the research purposeful and innovative.

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## **ACKNOWLEDGEMENT**

This work was supported by the Slovak Research and Development Agency under the contract No. APVV-14-0336 and Scientific Grant Agency of the Ministry of Education of the Slovak Republic (ME SR) and of Slovak Academy of Sciences (SAS) under the contracts No. VEGA-1/0559/14.

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# Selected Aspects of Using Text Mining

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## Abstract

*This paper deals with information and knowledge obtaining for decision-making purposes from a large volume of structured and particularly unstructured data, which is stored in the electronic form, either in information systems or on the Internet. Intention of the paper, which is based on the analysed literature, is to formulate Text Mining tasks suitable for usage in the university environment, to find appropriate software for the task solving, to give examples of solutions and to evaluate its practical application. The main objective is to create an overall assessments' overview of selected final theses defended at the Department of Information Management in the years 2001/2002. The main objective is met by achieving several partial objectives: theoretical background analysis focusing on Text Mining and Data Mining, selection of available and appropriate software and performing a manual check of selected reviews after the creation of the overall assessments' overview. After evaluating the available text mining programs and their applicability, strengths and weaknesses, Statistica software, is chosen from among the programs. Text Mining requires a specific approach to data pre-processing, as well as data processing. When the specific approach is applied in symbiosis with the appropriate software, the desired outputs are achieved with permissible error and Text Mining becomes a useful tool to make processes more effective.*

## Keywords

*Knowledge. Business Intelligence. Data Mining. Text Mining. Big Data. Structured Data. Unstructured Data.*

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## INTRODUCTION

The current period is characterised by the emergence of a knowledge society, which is based on the pillars of education, learning, science, research and innovation, informatisation and digitalisation. Principles of the knowledge society are closely connected with modern information technology and the use of knowledge as an economic resource. In the business environment, these facts are manifested by managers, who need to perform reliable and timely decisions based on relevant documents and require faster and easier access to information stored both in the enterprise information systems and in external files published on different types of information sources, such as websites (Kapusta et al., 2015) and e-mail communication. Business Intelligence software tools (BI), which have been gradually implemented in enterprises since the 90s, are characterised by a set of processes, applications and technologies designed to effectively and efficiently support the decision-making processes in the enterprise. They are intended to support

analytical and planning activities of enterprises and organisations, and are based on the principles of multidimensional views of business data (Elbashir and Williams, 2007; Kowalczyk, and Buxmann, 2015; Wang, 2016). BI systems “combine software tools, technologies and methods in order to obtain the key information required for management to increase profits and business performance” (Hamranová, 2013).

The original system architecture represents systems, applications and management processes that ensure a transfer of data from source systems, their storage, processing and transformation into information and knowledge designed to support decision-making process. The basic elements of architecture are technologies that conduct (Hamranová and Romanová, 2013):

- Data management in order to ensure timely and accurate information,
- Transformation processes, whose role is to clean, validate and transform data into a uniform format,
- Data storage that is designed to effectively and securely store data including metadata,
- Analytical tools and applications including: OLAP tools (Online Analytical Processing), statistical and quantitative algorithms, Data Mining tools, Text Mining tools, simulation tools.

Data processed in information systems, which represent a source for the BI systems, are divided into structured, semi-structured and unstructured data. Such data is currently covered by the concept of Big Data. Big Data means a set of data, whose size is beyond the ability to capture, manage and process data using common software tools within a reasonable time. The amount of data is understood not only in terms of volume, but also in a complex three-dimensional context referred as the 3V (Lacko, 2013):

- Volume – expresses the exponentially growing amount of data within a particular business area,
- Variety – information differs in numerous types, sources, formats, structures, coding, syntax, etc.
- Velocity – a speed at which data originates, a need for its real-time analysis.

The paper presents selected analytical tools, especially Data Mining and Text Mining, which are a part of a presentation layer of the BI architecture. These advanced tools, designed for knowledge extraction from large volumes of data, are successfully used only if quality (Managementmania, 2015) and data security (Beláňová, 2015) is assured.

The main objective is to create the overall assessments’ overview of selected final theses defended at the Department of Information Management in the years 2001/2002. The main objective is met by achieving several partial objectives: to analyse theoretical background focusing on Text Mining and Data Mining, to select the appropriate software tool and to perform the manual check of selected reviews after the creation of the overall assessments’ overview.

## **DATA MINING**

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Data mining is a nontrivial extraction of hidden, previously unknown and potentially useful information from data (Fayyad, 1996; Kalegele et al., 2015). Expert systems, methods of artificial intelligence and machine learning, statistical, graphical and visualisation techniques are used to detect new information, which is presented to people in an understandable way. Information is often deeply hidden in extensive databases containing data stored for several years. In many cases, data is cleansed and consolidated in data warehouses. Data Mining environment is usually based on the client - server architecture or the web information system. The aim is to create a mining model that supports decisions in the issue. Ideally for Data Mining, data is obtained from the data warehouse, which is a database designed especially for the analytical requirements and contains data from various sources, pre-processed and historical data. Knowledge acquired from Data Mining might be, for example in the form of rules obeyed by the enterprise; it will not repel customers by meaningless offerings, but attract them by attractive offerings. The rules are one of many forms of knowledge and especially comprehensible knowledge to a human. Many rules may be established by traditional statistical methods, but in practice, statistics frequently fail because of a hidden individuality of specific cases. A result is a numeric representation of properties of a whole, respectively, individual major parts of the whole. Furthermore, conditions for the use of statistical methods are not followed in many cases.

Currently, there are two general methodologies that describe each step of Data Mining:

- SEMMA methodology – Sample, Explore, Modify, Model and Assess (Brown, 2015), developed by SAS Institute Inc.,
- CRISP-DM methodology – Cross Industry Standard Process for Data Mining (Chapman et al., 2000), developed by SPSS Inc.

## **TEXT MINING**

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Text Mining is a scientific discipline that develops with a growing need for automated processing of large volumes of data available in the form of free text. Standard Data Mining methods work only with structured data (textual, numerical, categorical, etc.) that contains relevant metadata for processing. According to Bhavna (2015), a lot of information remains inaccessible because 80-90% of the potential use of data is stored in the unstructured form.

Text Mining uses techniques of Data Mining, Machine Learning, Natural Language Processing (NLP) and knowledge management. Unlike Data Mining, it is engaged in unstructured data processing (such as the free text). According to Feldman and Sanger (2007), the role of Text Mining consists of the following elements: text categorisation (on the testing data), text clustering (merging documents into clusters according to similarities), summarisation (selecting the most important parts of the text, creating a content of the extensive document), information extraction (retrieving structured data from the free text; a typical example is Web Mining; a typical function is an address recognition and extraction from the free text), sentiment analysis (distributing documents according to emotional content, extracting author's attitude towards the text, estimating author's characteristics –



age, sex, education), recognition of named entities (disambiguating word meanings) and relationship determination between the entities (individuals, enterprises).

Based on different approaches, Text Mining methods are divided into:

1. Statistical

- Text is perceived as a sequence of data that are not dependent on a particular natural language,
- There is no lexical and semantic analysis,
- No linguistic sources and methods are necessary,
- Algorithm does not need to “understand” the text.

2. Linguistic

- Text is dependent on a language,
- Relationships between words are being examined,
- Analysis of synonyms is being conducted, lexical and semantic disambiguation (removing uncertainty of words’ meaning), part-of-speech tagging (POS),
- Algorithm using linguistics and its sources.

The following characteristics are typical for statistical methods: the text is seen as a sequence of data that are dependent on a particular natural language; lexical and semantic analysis is not performing; linguistic sources and methods are not necessary and algorithm does not need to “understand” the text. Linguistic methods are characterised by the following features: text depends on a specific language; relationships between words are examined, synonym analysis is performing; lexical and semantic disambiguation of word forms with multiple meanings; POS; algorithm uses linguistics and its sources (dictionaries, corpora) and “understands” the nature and the lexical meaning of the text.

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## METHODS

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There are many applications of Text Mining in the market aimed to analyse simple texts, for example to determine the occurrence or frequency of words (such programs unfortunately do not manage to process large volumes of data), and universal software of Data Mining, where Text Mining is integrated (these are generally expensive). Besides this group, there is a wide range of open-source programs, e.g. GATE, LingPipe (which has a limited functionality), Open Calais and RapidMiner.

After assessing the availability, strengths and weaknesses, Statistica software from a StatSoft corporation, version 13, was chosen for our research. A user-friendly interface and a possibility of a trial version were the main reasons to select Statistica. Software enables to apply Text Mining, as well as Web Crawling. Statistica supports importing documents in multiple formats (.txt, .pdf, .ps, .html, .xml) and most Microsoft Office formats (.doc, .rtf, .xls). Analysed documents may be pre-processed before indexing process begins or at the same time. During the process, it is possible to apply rules for the elimination of function words. It is called a stop list (in Slovak language, stop words are for example prepositions, conjunctions, interjections, particles, etc.). If the built-in stop list in case of a supported language is not available, the stop list may be manually created.

Statistica supports a relatively large number of input languages (Danish, Dutch, English, French, German, Italian, Portuguese, Spanish and Swedish). Slovak language is not supported, but the Slovak stop list may be acquired on the Internet (Laclavik, 2011) or supplemented by own words. Besides, it is possible to create a list of words, whose meanings are formed by a combination of several words. For this reason, Statistica software is used in other languages as well.

After selecting the application software, Text Mining was conducted in several stages related to the CRISP-DM methodology:

1. Source file creation (text selection and pre-processing based on the reviews of defended theses in the academic year 2001/2002, a research sample of 126 reviews),
2. Stop list selection and modification, setting a combination of words,
3. Text Mining process implementation, indexation,
4. Reports and presentation of results (Statistica summary tools: Frequency matrix: word – document, Selected words, Indexed documents, As report),

## RESULTS

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The research problem is to create the overall assessments' overview of selected theses defended at the Department of Information Management in the examined academic year. Assessments of theses are presented in the reviews and are expressed in words: excellent, very good, good, satisfactory and sufficient. Reviews were written in MS Word at the start of the assessment period. Moreover, standardised review forms were not always created in a uniform format and were changed in different years. Subsequently, the reviews have been converted to a PDF format. Text Mining method is selected for this reason and applied to the selected sample of 126 reviews.

CRISP-DM methodology is used in our case of Text Mining. The first phase of this method, especially the text selection and pre-processing, is simplified to find and select individual assessments, to make them anonymous and to store the assessments in one folder. In order to obtain good quality results (particularly in the languages that use declension and conjugation), it is necessary to pre-process the text by stemming and lemmatization methods. Stemming determines a root form of a word. From the morphological point of view, it represents finding and removing word suffixes that change due to declension and conjugation, removing prefixes and diminutive words. Lemmatization determines a basic, standardised word form. Unlike stemming, the result of the lemmatization is a grammatically correct word. In those languages, which use declension and conjugation minimally (e.g. English), a difference between stemming and lemmatization diminishes. In our case, we departed from these methods because we focused on detecting the presence of the exact words reflecting the assessment (excellent, very good, good, satisfactory and sufficient). Other modifications of the words were not taken into account. Therefore, they could not affect the results.

This phase is followed by the stop list selection and modification ("stop\_slova.txt" file), and the file setting a combination of words. In our case, this file contains only one combination: "very good" ("vel\_dob.txt" file). Consequently, the process of Text Mining is

ready to be initiated, i.e. indexing process begins by pressing the Index button. The procedure is shown in Figures 1-3.

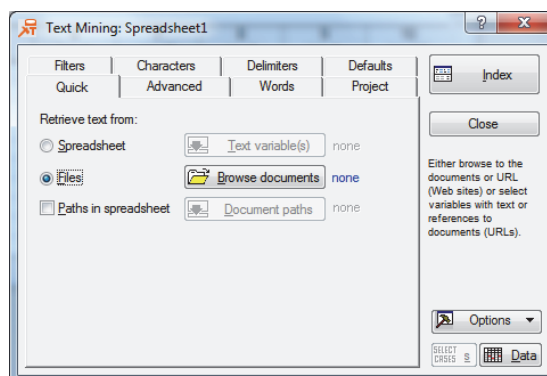


Figure 1: Quick tab used to select files for the analysis

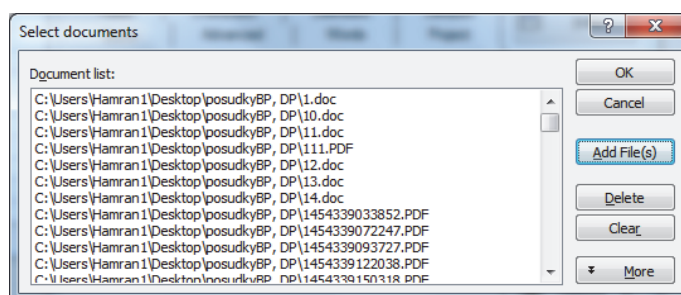


Figure 2: Selected files

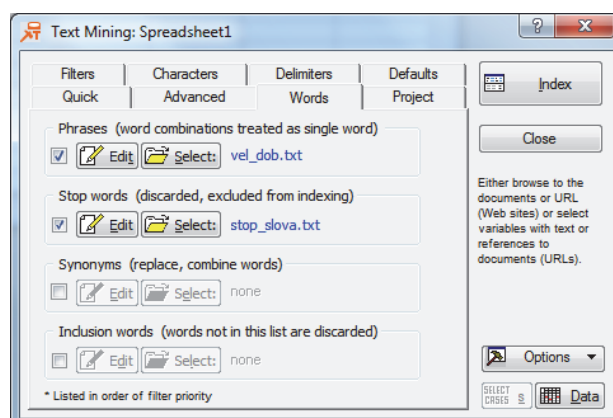


Figure 3: Words tab

The overall result is shown in Figure 4. Furthermore, the result may be observed in several views: Frequency matrix: word – document; Selected words; Indexed documents; As reports. The summary of “Selected words”, where the important words, such as excellent (Figure 5), very good, good, satisfactory and sufficient are looked up, is appropriate for our needs. The summarised results are presented in Table 1. The final check reveals that the error of Text Mining is 0.015%.

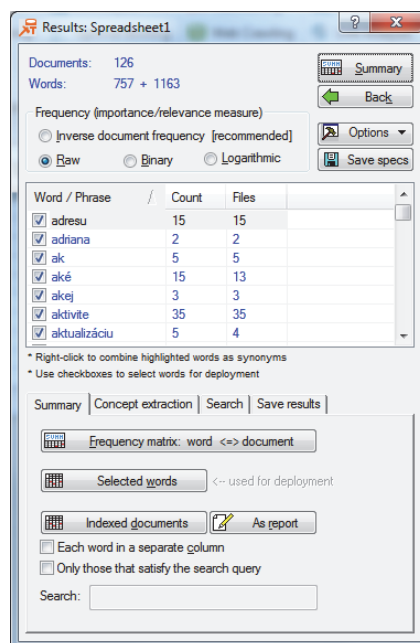


Figure 4: Text Mining results

Words summary (Spreadsheet1)		
Word / Phras	Count	Number of documents
vedúceho	146	41
vedúci	68	34
vedúcim	34	34
veľké	2	2
veľkých	2	2
veľmi dobre	41	41
venujete	3	3
verejnej	3	2
veronika	2	2
vhodnosť	153	126
viaceré	2	2
viacerých	4	3
vidíte	4	4
vilem	2	2
vladimír	3	3
vlastné	2	2
vlastného	22	22
vinnate	2	2
voľba	8	8
vplyvu	2	2
vrátane	67	67
všetky	3	3
výber	3	3
<b>výborne</b>	<b>47</b>	<b>47</b>
učebná	3	3

Figure 5: Results of a specific assessment (“výborne” – excellent)

Subsequently, the obtained results of the Text Mining report are compared with the manual check. Text Mining was accomplished in 3 seconds, whereas the manual check lasted 35 minutes. The error of Text Mining occurs in two cases and only in the assessment of “good” (C).

Table 1: Assessment comparison between Text Mining and the manual check

Assessment	Text Mining (Duration of 3 sec.)	Check (Duration of 35 min.)
Excellent (A)	47	47
Very good (B)	41	41
Good (C)	16	14
Satisfactory (D)	14	14
Sufficient (E)	10	10

## **DISCUSSION**

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There are various views on the approach towards the process of knowledge discovery in a collection of text documents. We implemented interactive and iterative process of obtaining valid, useful (for the selected application) and by now unknown knowledge. The used algorithms gain valid patterns of different types, whose interpretation and assessment of usefulness is left to the human being.

The results achieved through the in-depth analysis are an irreplaceable source of information as relevant patterns and rules are selected from the large amount of data. These results assist to take the necessary decisions effectively.

Statistica software provides an advanced interface that is easy to use. Software successfully dealt with the content analysis of documents. The appeared result displayed the prompt summary of reviews' contents without the need for a detailed reading of reviews.

In addition to the software application in the academic environment, Text Mining is used in the commercial sector as follows:

- Spam filters, automatic e-mail sorting by similarities,
- Determining the extent of plagiarism (assessing document similarities), author determination,
- Competition examination – automatic competitor's website processing in order to obtain information about its activity,
- Social networks' comments or reviews monitoring in order to monitor customer satisfaction.

## **CONCLUSION**

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Text analysis has also several disadvantages. The limitation of the Text Mining process is the uncertainty of the results, which is affected by the fact that the text processing eliminates the human being because it is managed by the specific software. Furthermore, software is used without a support of Slovak language. Text Miner Statistica needs to complete logical connections, the combination of words, phrases and the stop list. After obtaining the output, knowledge of the test sample is necessary to interpret the results correctly.

Generally, the text analysis is not perfect and faces many difficulties. One of them is the text itself, because it is not designed to be processed by a computer as a priority. Data is inappropriately structured or not structured at all. Moreover, the text has a complex semantics and is often accompanied by several meanings.

For these reasons, Text Mining requires a specific approach to data pre-processing, as well as data processing. Text analysis is still a task that cannot be correctly accomplished by a machine. Human being must be involved in the process of analysis because of the logical thinking. When the specific approach is applied in symbiosis with the appropriate software, it is possible to achieve the desired outputs with permissible error, and thus Text Mining becomes the useful tool to make processes more effective.

## ACKNOWLEDGMENTS

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The research and the paper are supported by the Scientific Agency VEGA through financial support of the Project No. 1/0336/14 at the University of Economics in Bratislava.

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# Spatial Avalanche Modelling by Application of Geographic Information System

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## Abstract

*The avalanches represent a significant and very dynamic process within the Tatra high-mountain landscape. Undoubtedly avalanche run-out distances play a key role in land use planning within avalanche prone areas. The Žiarska valley in Western Tatra Mts. and Predné Meďodoly valley in Belianske Tatra Mts. are considered as one of the most avalanche prone valleys in the whole area of Carpathian Mountains. This environment represents an excellent opportunity for studying and modelling extreme avalanche run-outs. The valley is frequently visited by backcountry skiers and several roads and cabins are located there as well. This requires a detailed land use planning with regards to the extreme avalanche run-out. Primarily avalanche release zones were estimated by using an existing model proposed by Hreško (1998). This model was modified and calibrated with the use of avalanche data extracted from a database maintained by Slovak Centre for Avalanche Mitigation. The alpha-beta regression model developed in Norway has been used to estimate avalanche run-outs. This model is calibrated for use in Western Tatra Mts. and Belianske Tatra Mts. Topographical parameters from well known extreme avalanche paths have been collected using GPS. Data processing and model calibration have been elaborated in geographic information system (GIS) environment. Avenue script for ArcGIS was written to perform automated run-out estimation based on alpha-beta regression model. Model managed to estimate run-outs on some slopes while it failed to model run-ups. Finally the results were visualized by creating the fly-through simulations and 3D views. Winter season 2008/2009 with disastrous avalanches showed the importance of avalanche run-out modelling. Numbers of installations have been damaged due to improper land use planning without respect to extreme avalanches. Comparison between model calculation and avalanche cadastre showed correlation.*



**Keywords:**

*Snow avalanches. Geographic information system. Run-out modeling. Data analysis.*

## **INTRODUCTION**

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In the course of several decades estimation of avalanche run-out based on topographical parameters has been carried out in some countries within Europe and North America. Early attempts were taken in USA (Bovis and Mears, 1976) and Norway (Lied and Bakkehøi, 1980). Since then in many countries and mountain ranges in the world (Fujisawa et al., 1993; Furdada and Vilaplana, 1998; Johannesson, 1998; Barka, 2003; Jones and Jamieson, 2004; Lied et al. 1995; Delparte, 2008) the so called alpha-beta regression model (Lied, Bakkehøi, 1980) has been introduced. Later on with advance of computers and geoinformatics and their application within natural hazards zoning, GIS has been widely adopted. Terrain models (Toppe, 1987) and GIS have been used either to estimate the probable avalanche release zones (Hreško, 1998; Maggioni, Gruber, 2003), model avalanche run-outs (Barka 2003; Delparte 2008) or asses the protective function of forest against avalanches (Bebi et al., 2001).

Four thousand avalanche paths are registered within five Slovak mountain ranges. Several hundreds of the avalanche tracks intersect with the roads, hiking trails and places often frequented by winter travellers and backcountry skiers. Avalanches have been observed during last 50 years and their findings have been documented either in written form or drawn into avalanche cadastre maintained by Slovak Centre of Avalanche Prevention (SCAP). Several disastrous avalanches with extreme run-outs occurred for last 15 years and most of them exceeded the borders of well-known avalanche paths.

So far several works dealing with estimation of probable avalanche trigger zones using GIS have been elaborated in Slovakia (Hreško, 1998; Barka, 2003; Barka, Rybár, 2003; Hreško, Bugár, 2000; Hreško, Boltižiar, 2001; Boltižiar, 2007). Most of them were carried out as part of research at local universities or institutes. The aim of this work is to use the GIS techniques for estimating probable avalanche trigger zone and model run-outs on selected slopes. Simple equation model (Hreško, 1998) for release zones is implemented and used to automate the mapping of release zones in GIS. The model calibration has been based on data from Avalanche database maintained by SCAP. Avalanche path model uses statistical regression model described by Lied and Bakkehøi (Lied, Bakkehøi, 1980). The model is implemented into GIS by script written in Avenue programming language. Despite that the model failed to accurately represent run-ups and curved channeled paths; it has functioned well with linear straight down sloping paths.

## **RESEARCH AREA**

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Ziarska valley is situated in Western Tatra Mts. and Predne Medodoly valley is situated in Belianske Tatra Mts. Both valleys have very similar conditions for the formation of avalanches. This relates to their overall geomorphological conditions. From all of our high mountains, they have the greatest topographic suitability for the formation of avalanches, especially in terms of size and frequency. The decisive factor is the overall morphology of avalanche gullies, especially length and position of the cut-off zone, size of

the catchment area, length and slope of avalanche paths and vegetation conditions. According to SCAP avalanche cadastre the length of avalanche paths is approximately 500-2000 m and height difference is 300-950 m. Particularly favorable conditions in these mountains are given by the lowering of upper forest boundary and destroying the dwarf-pine zone because of very long extensive use of these areas for grazing sheep and cattle. On the long and steepest section of avalanche path, i.e. from the cut-off zone to the upper forest boundary, the avalanches grow not only in size, but especially in dynamic forces. Their dynamic effects cause that the current forest area is cut through to the bottom of the valleys which shows not only their occurrence, but also destructive effects. The effects of avalanches were continuously monitored in the context of conducted field surveys which were associated with the photodocumentation.

## **METHODS**

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### **Statistical analyses of avalanche database**

Avalanche database contains information on avalanches that has occurred within the territory of Slovakia. The database consists of information on release zones (elevation, exposition, aspect, type of snow etc.), transport zones (shape, topographic parameters), deposition zones (shape, height, type, etc.), casualties and damage (number of people involved and injured, deceased, forest damages). First record is dated to 1937. For the purpose of release zones identification, relevant information (aspect and elevation of release zones) has been extracted from the database. Based on these parameters avalanche trigger zones model has been calibrated.

### **Data sources and pre-processing**

The accuracy of the model results complies with accuracy of data inputs. Therefore relative high accuracy of data inputs is required. Both models are based on topographical factors which requires accurate digital elevation model (DEM). 5 m interval contours were used as a base for creating DEM. For Žiarska valley they were scanned from "The base map of Slovak republic" at scale 1:10 000 and for Predné Meďodoly valley also generated by photogrametric methods (Euro senses s.r.o., Bratislava, SK). Consequently contour lines were vectorized and DEM was computed using spline function with tension (Mitášová, Hofierka, 1993). Because of the presence of artificial undulations in the DEM (profile curvatures varied from concave to convex around contours), DEM preprocessing was performed. Random points with elevation attribute were extracted from the DEM. Points from valley bottoms contours (in strips 20 m wide on each side of thalwegs) were added to random points. As a result new elevation data points were created. Compared to general fill method this way of DEM creation prevents generation of depressions in the valleys. It can be argued that there are more accurate ways of digital elevation model creation e.g. digital photogrammetry, aerial or terrestrial laser scanning or geodetic survey, but these methods are much more costly and time consuming. Land cover layer obtained by analyzing the large scale vegetation maps (1:10 000) and aerial imagery were another important data inputs for estimating terrain roughness.

## Probable avalanche release zones model

Avalanche trigger or release zone can be described as areas with certain topographical features which allow deposition of snow masses. These snow masses tend to release as snow avalanche until certain conditions. Hreško (1998) proposed simple equation model for avalanche release zones estimation. The equation and model factors were modified according to the results of statistical analysis of Avalanche database. This step was done to link the real avalanche situations with the proposed model (1):

$$Av = (Al + Ex + Fx + Fy) * S * Rg \quad (1)$$

where Av is value estimating potential avalanche trigger zones, Al is elevation factor, Ex is aspect factor, Fx is profile curvature factor, Fy is plan curvature factor, S is slope inclination factor and Rg is roughness factor.

Factors of slope angle and terrain roughness are the most important ones. They determine possibility of the avalanche initiation, while the other factors influence the frequency of avalanche occurrence only. So called "the critical slope angle" (which is the minimum slope angle value necessary to avalanche initiation) is usually referred to be 10°. Optimal slope is between 35° and 45°, above 70° snow cover can not develop. Grass areas, soil without vegetation cover and rock plates are generally considered to be the surfaces most liable to avalanche initialization. Dense forest reduces initiation hazard to minimum. Thus roughness factors values respond to these facts. Snow cover thickness increases usually with elevation above sea level in Western Carpathians region, and that's why the elevation factor values are higher in the highest parts of the area in question. Slope aspect has two different means – exposition to solar radiation and exposition to prevailing winds. Solar radiation controls properties of snow cover and prevailing winds its spatial distribution. Aspect factor values are therefore expected to be higher at leeward hillslopes, usually faced toward south and east in Western Carpathians. Tangential curvature factor represent spatial distribution of snow cover too, which is usually thicker in chutes or on slopes rather than on ridges.

Land cover layer and DEM are two main data inputs for model calculation. Each of the factors (Al, Ex, Fx, Fy, S, Rg) were classified according to table 1 and using map algebra the final grid layer (Av) was calculated. The classification was based on the data extracted from the avalanche database. According to the database the lowest avalanche frequency is observed in the interval from 1200 m -1450 m. Therefore this interval got score of 0,1. The same for other factors (plan and profile curvature, land cover etc.). The complete methodology of the classification can be found in studies done by Hreško (1998), Barka, Rybár (2003), Boltžiar (2007).

Each factor gains ball values between 0 – 2, 0 – 3 respectively (terrain roughness - Fg) – (Table 1). Maps of corresponding factors values have to be prepared within raster oriented GIS (e. g. GRASS Open Source GIS, ArcView, ArcGIS, Spatial Analyst or Idrisi). Resultant map of avalanche initiation hazard can be obtained by usage of map algebra and reclassification of computed values (see Table 2 and Map 1). Consequent reclassification according to the table 2 resulted into final grid layer which represents avalanche prone areas. Avalanche prone areas are reaching higher values of Av.

ArcGIS was used to fully automate probable trigger zones estimation by using model builder module. For consequent avalanche run out modelling the zones reaching the  $A_v$  value at least 22,5 or more were selected. The final output was compared with avalanche cadastre map, visually assessed and imported into ArcScene to create 3D bird's eye views for Žiarska valley (Figure 4).

Table 1: Factors used to estimate trigger zones.

Elevation (m a. s. l.)	Elevation Factor(AI)	Plan Curvature	Curvature Factor(Fy)	Profile Curvature	Curvature Factor(Fx)
1200 - 1450	0,1	-4 – -0,2	1	4 – 0,2	1
1450 - 1700	1	-0,2 – 0,2	1	0,2 – -0,2	1
1700 - 1950	2	0,2 – 0,5	1	-0,2 – -0,5	1
1950 – 2200	0,5	0,5 – 4	0,5	-0,5 – -4	0,5
Cover type				Roughness Factor (Rg)	
forest (coniferous, deciduous, mixed)				0,5	
open forest with dwarf-pine, rough stony debris and slope covered by lesser blocks				1,2	
deciduous shrub wood				1,4	
open forest				1,5	
dwarf-pine and slope with juts of parent rock under 50 cm				2,5	
grass with sporadic dwarf-pine, and small size slope debris				2,8	
compact grass areas and rock plates				3	
Slope (°)	Slope Factor (S)	Aspect	Aspect Factor (Ex)		
0° - 10°, 70° - 90°	0	N	0,8		
10° - 19°, 60° - 70°	0,4	NE	0,5		
19° - 25°, 55° - 60°	0,8	E	0,7		
25° - 30°, 50° - 55°	1,2	SE	1,5		
30° - 35°, 45° - 50°	1,6	S	2		
35° - 45°	2	SW	1		
		W	1,7		
		NW	0,4		

Table 2: Final reclassification.

Equation (1) result $A_v$	Avalanche trigger hazard
0 – 15	Low
15 – 22,5	Medium
22,5 – 30	High
30 – 36	Very high

## Avalanche run out modelling

For the purpose of this work model developed in Norway by Lied and Bakkehøi was implemented into GIS. Model predicts maximal avalanche run out, using terrain parameters of the avalanche chute. Avalanche dynamics is not taken into account. The authors based the model on analyses of hundreds of well known avalanche chutes. They chose a reference point (so called the  $\beta$  point) with  $\beta$  angle defined as the average

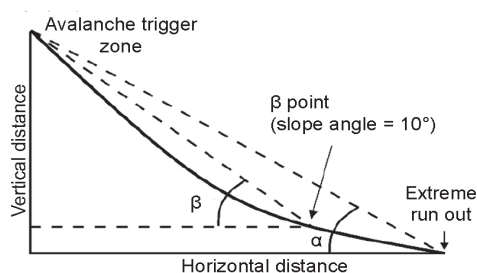
gradient of the avalanche path profile from the position where the slope decreases to  $10^\circ$  to the trigger zone (Figure 1).

The  $\alpha$  is the angle sighting from the extreme run out position to the triggerzone. Least square regression analysis (2) showed correlation between  $\alpha$  and  $\beta$  angle and the relation have form of equation (Lied, Bakkehøi, 1980).

$$\alpha = C_0 + C_1\beta \quad (2)$$

Model was calibrated on dataset of 44 avalanche paths from both valleys (30 from Žiarska valley and 14 from Predné Medodoly valley) with well-known run-outs. With the assistance of avalanche expert knowledge of J. Peťo from SCAP maximum run outs were measured in terrain using GPS. Survey of aerial imagery accompanied the fieldwork to increase the accuracy of measurements. Topographical parameters of each path were extracted in ArcGIS and linear regression analysis performed using statistical package NCSS. Acquired regression coefficients together with avalanche trigger zones (where  $A_v \geq 22,5$ ) served as the input parameters for script written in Avenue for ArcGIS. This script models avalanche movement as flowing water. It creates flowlines from certain points (avalanche trigger zones) than it finds  $\beta$  points calculates the  $\beta$  angle and consequently based on the equation 2 it estimates  $\alpha$  angle. Later it estimates  $\alpha$  point and cuts flow-line at this place. Script runs automatically and beside the input points it needs DEM in form of TIN. Because the avalanche movement is modelled as water some problems are raised. At one point all the flowlines connected and continued as one flowline which is natural behaviour of the water but not common to avalanches. This was solved by channel network module in SAGA GIS. The module derives a channel network based on gridded digital elevation data and enabled to keep all the separated flowlines in one flow similar to the flow of avalanches. The proposed method enabled almost automated estimation of avalanche paths. Due to the lack of time and computer capacity the method was used only on selected slopes.

Figure 1: Topographical run-out model.



## RESULTS

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Results from the model estimating probable avalanche paths correlates well with avalanche cadastre map (Figure 6). It was expected that trigger zones estimated by the model will occur in upper parts of historical avalanche paths. Due to the forecast succession 10 % of the avalanche trigger areas are not avalanche prone anymore. This is due to the growth of mature forest on such places which is perfect avalanche barrier. The up to date land cover layer used in the model influenced the result so the areas were

properly estimated with lower avalanche trigger possibility. Field investigation and aerial imagery inspection indicated large forest succession in these places for last 25 years. Due to this succession avalanche activity was reduced to minima. Use of the up to date land cover maps and orthophotos as an input for the model resulted in the proper estimation of potential avalanche trigger hazard. Model revealed that in Žiarska valley: 68 % of the studied area falls into the zone with small avalanche trigger potential; 21 % with medium; 10 % with high and 1 % as very high avalanche trigger potential and in Predné Meďodoly valley: 62 % of the studied area falls into the zone with small avalanche trigger potential; 14 % with medium; 14 % with high and 10 % as very high avalanche trigger potential. (Fig. 4). Due to the implementing the data from avalanche database and curvature factor, estimated release zones reflects the nature of avalanche triggering (Figure 2, 3). Ridges were properly classified as places with minimal avalanche trigger potential (Figure 5). On the other hand high or very high risk potential was given to the steep gullies and vast steep slopes covered with grass. This is one of the reasons, why Predné Meďodoly valley has more “very high” avalanche release potential areas.

Figure 2: Avalanche release potential within studied sites.

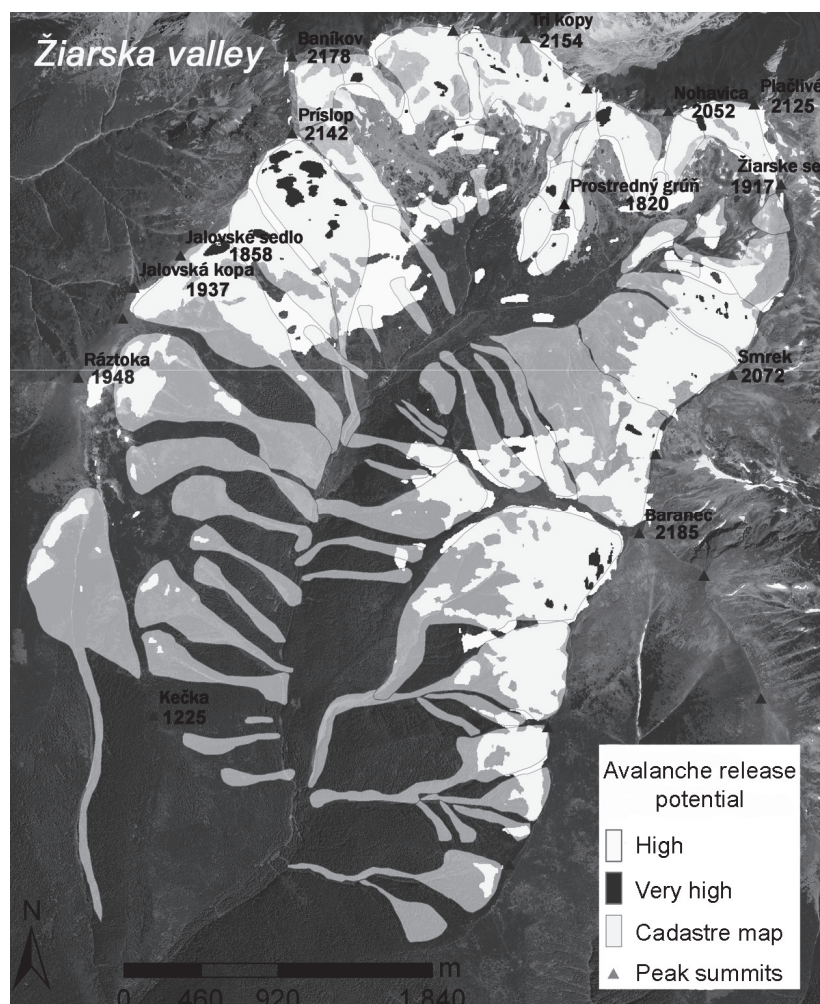
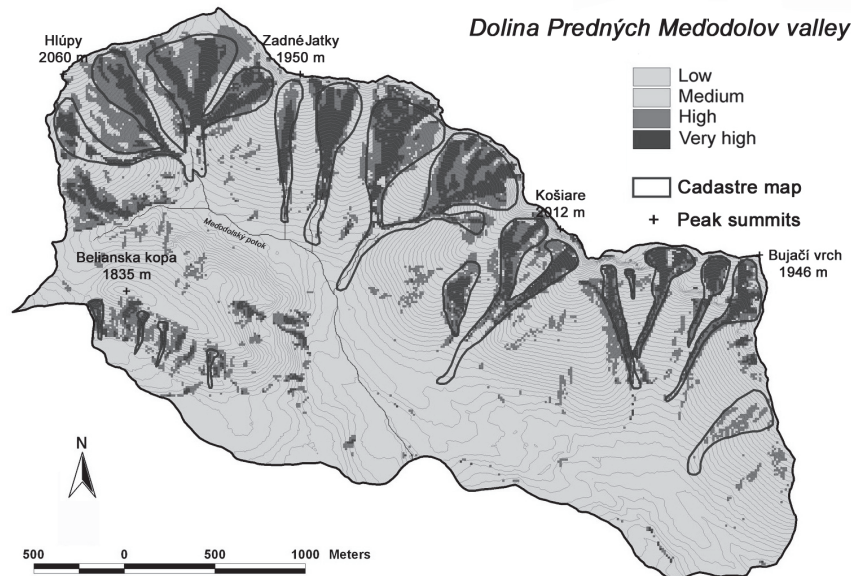


Figure 3: Avalanche release potential compared with cadastre map.



### Avalanche run-outs

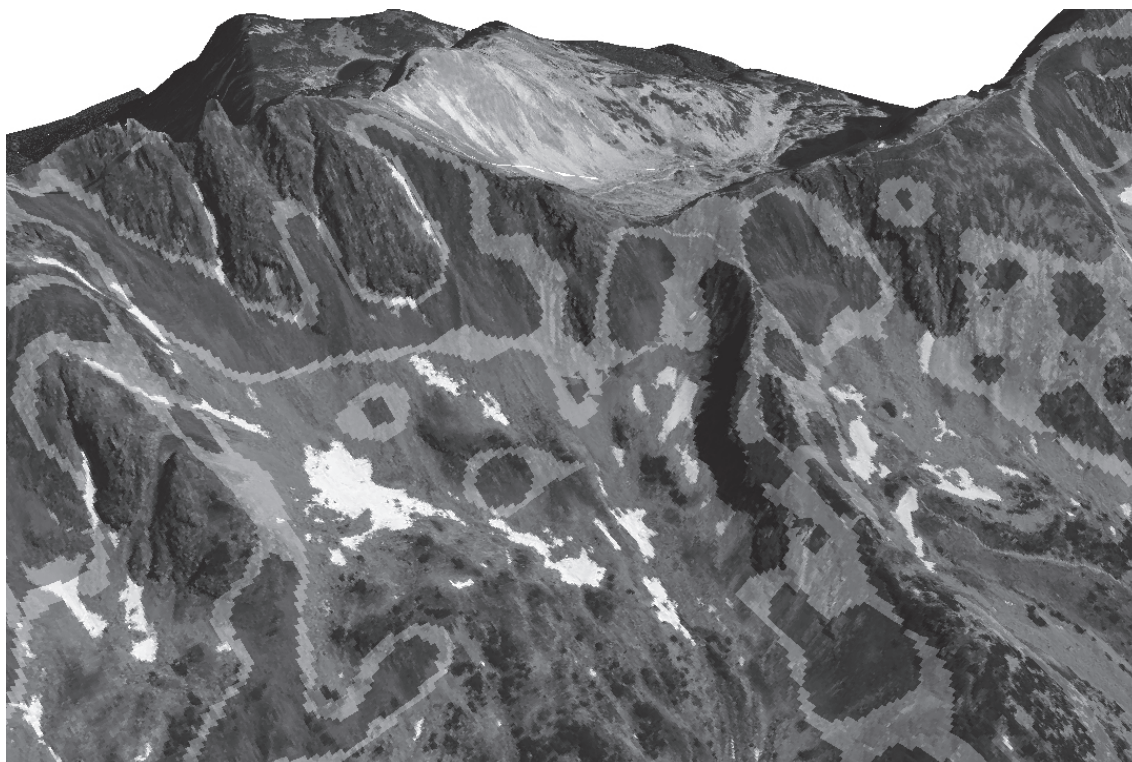
Use of scripting language (Avenue) in GIS allowed implementing statistical run out modelling in automated way (3). This was done on selected slopes. The final regression equation for the Western Tatra and Belianske Tatra Mts. is

$$\alpha = 0,91\beta - 0,04^\circ \quad (3)$$

Correlation coefficient for this regression is 0,95 coefficient of determination is 0,9 and standard error of predicted  $\alpha$  angle is 1,1. Figure 6 shows final run-outs on all avalanche paths in both valleys. It can be stated that in this case model outputs are in good correlation with historical avalanche cadastre map. In some other cases model failed to represent run-outs naturally, e. g. run-ups and channeled curvy run-outs. Because the avalanche movement was approximated as water flow, circumstances occurred in narrow channels where all the flowlines gathered together and from certain point they flowed together. This was partially solved by channel module in SAGA. Unfortunately in some extremely curved channels satisfying results were not obtained and different methods should be used for determining avalanche width.



Figure 4: High and very high avalanche release potential in Žiarska valley (3D view in ArcGIS).



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## CONCLUSION

The visual assessment of the avalanche trigger model shows agreement with avalanche cadastre in some cases. The model did not estimate several trigger zones located mainly in the lower parts of the valleys. 91% of the pixels marked as the avalanche prone area fits in the area of avalanche cadastre. In future more detailed observations and use of the satellite imagery will be required to obtain data on avalanche prone locations. This can be explained by the succession undergone in these trigger zones. Field investigation proofed that the trigger zones are naturally reforested and therefore avalanche activity is reduced. This conclusion is also supported by direct avalanche observations which did not report any avalanche for last 15 years. It is crucial to use the most up to date data on land cover because only this can guarantee the proper estimating of the actual trigger areas. The release zones evolve in space and time according to the development of the avalanche activity and the forest succession.

The avalanche trigger model is easy to implement into GIS environment. It is simple to calculate the model factors and after several improvements the model might be used in avalanche zoning. It will be interesting to see the future development of the model. In the operational use coupling the model with on line meteorological data could help to improve the results. Particularly it could enable to estimate actual trigger zones in real time depending on the weather situation. This would be a big help for people travelling in avalanche prone areas.

The alpha-beta regression model implemented into GIS showed several discrepancies with real behaviour of the snow avalanches. In many cases it was not possible to find the



beta reference point. This is caused by the relative steepness of the study region. Most of the avalanches do not reach the beta point and they terminate either on the steep valley bottom or the opposite slope. The model was devolved in Norway taking into account local topography which differ from topography in Western Tatra Mts. or Belianske Tatry Mts. It cannot be stated the model doesn't work at all. It works, but just for specific slopes. The model is suitable for straight down sloping paths with no run-ups in the depositional area.

The developed method for avalanche zoning showed that many improvements will have to be done to use this method for land-use planning. It is an advantage especially for avalanche zoning in small scales that models are implemented into GIS and can perform the simulations in automated manner. After the refinement and adjustment method can be translated to other mountain areas. The proposed method of estimation of avalanche prone areas seems to be good replacement of the method based entirely on the field observations. It saves a time and brings more safety for the stuff of SCAP. On the other hand avalanches are very difficult to predict and relying only on model outputs is not advisable. In some way the field observations will always be necessary.

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# Evaluation of Strategic Planning Process using Analysis of Fuzzy Integral

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## Abstract

*The paper is focused on the topic of evaluation of strategic plans on the municipality level. The evaluation of the SWOT analysis is chosen as a key aspect. On the example of the Strategic Development Plan of the city of Prague, Czech Republic, the authors try to present possible usage of the Sugeno  $\lambda$ -measure and Choquet fuzzy integral methods for the evaluation. As an input served not only key aspects of the Prague's SWOT analysis but also the performance of the city evaluated by the range of experts from regional economy, urban planning, social care and regional resilience. Linguistic variables Not satisfactory, Satisfactory and Very satisfactory are used for evaluating of the city performance instead of numerical values. Yager's fuzzy ranking method was used to transform these linguistic values to crisp values. The evaluation result of analysis is the aggregation of strength, weakness, opportunity and threats.*

## Keywords

*Choquet fuzzy integral. Evaluation. Fuzzy measure. Strategic planning. SWOT analysis.*

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## INTRODUCTION

Strategic planning (SP) is a powerful and efficient tool for government on all levels to define goals they would like to achieve and what might be more important - to design trails and activities that would lead to fulfil them. The SP was implemented in the US Army during the WWII as a tool that was supposed to prevent the system from investing rare resources into the activities that would not lead to the main goal of the war – to defeat the Axis military alliance. As a very efficient tool it moved from the military sector to corporate offices in the 50's of the 20th century where was further improved. Although some authors put the beginnings of the SP in the public sector into the 80's in the Great Britain (Bryson, 2011; Perlín, Bičík, 2006), we can find some earlier notes, in the United States (Eadie, 1983). But the Eastern Europe had to wait for this tool for more than thirty years.

The socialistic planning system was the centralized system that had nothing in common with the modern attitudes used by Western governments. The social-political changes in the late 80's and the early 90's in the Eastern Europe brought not only new freedom but also new challenges for citizens, companies and governance system as well. This paper is focused to the situation in the Czech Republic (CR) where the whole public sector was democratized; it was given the local power (and responsibility) to local governments and at the beginning of the new millennium also to new-established regional bodies. The enthusiasm for freedom and defiance the strict socialistic planning led to resignation to planning at all. In some cities were the years when the only valid plans were the budget (1 year) and master plan (focused strictly to spatial division of functions in the city and restricting the building activities). Such a situation was not sustainable. Therefore cities started to use at least 3 years-budget and economy outlooks. In the late 90's the 3-year outlook became to be not good enough for planning the city development and the "new" tool - economic development plans – were adopted. But these documents were still focused to economic issues. As the end of 90's of the 20th century were in the CR the years of rising economic and social problems there was the demand for new attitudes of governance.

This was also the time when the principles of sustainable development started to be implemented around the globe. The sustainable development was defined as '...development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Brundtland, 1987). Those principles were supposed to be implemented by the Agenda 21 and following local Agenda 21 that used the principles of new- and good-governance, the governance involving local actors, local stakeholders and the new tool for implementation – the SP (Šilhánková, 2004). The first SPs in the forms as we know them today were developed in cities of Vsetín (2003) and Hradec Králové (2004). The SP in the western countries undergone the huge development at the end of the millennium as well. There was also the delegation of power to local level and the planning agenda in the cities were rising (Gordon, 2005). Contemporary systems of SP in public sector are on the similar level in the CR as in other western countries. Nevertheless it has its national and local specifics.

The contemporary definition of the SP is different in public sector. One of them is 'The SP might be characterized as a tool for development of any organization (institution, authority, company, town, city), that, using the analyses and system of following steps, is systematically reaching positive changes. The SP in the public sector is the specific part of the discipline.' (Šilhánková, 2007). A wider definition describes SP as '... a process when it is created (in cooperation between establishment of the organization, the employees, board of directors, city board, specialists and other stakeholders who have an important role in the city or organization) the idea of the goals of organization, its main functions, development targets, programs and services that would be provided and what journey organization or city need to pass to achieve the goals and aims.' (Rektořík, Šelešovský, 1999).

Many states and other local government organs agree that SP is a process of developing a long-term plan to guide an organization, for example, a state agency, department or commission, towards a clearly articulated mission, goals and objectives. It is a process of assessing where an organization is presently, ascertaining the challenges and opportunities that present themselves, and determining what destination is most

desirable and how to get there (Young, 2001). The SP can be defined as a system of elements and relations between them that a set of elements can be characterized by triple. The set in themselves are expressing these following questions: Where the organization is? Where it wants to be? and How to get there? (Bryson, Alston, 2005, p. 5; Bryson, 2011, p. 11) or What it wants to accomplish? What are your capabilities? and What is needed and feasible? (Barry, 1997, p. 7).

In the Czech planning practice, there is no legislation rule how to create a strategic development plan or how the document would look like on the local level. But there is the framework that would follow all the authors: data collection, surveys, researches and thematic analyses – SWOT analyses (analytical part); vision – goals, aims, (strategic part); actions and activities (action part) and a part of implementation, management, measurement and evaluation (Šilhánková, 2007).

Strategic evaluation (SE) is as significant as any other SP process. This process is ongoing throughout the existence of an organization. It answers such questions as: is the strategic plan appropriate? Is the plan being implemented properly? Is the plan guiding the organization to achieve its mission, vision, and goal? How is the organization performing? Does the plan need to be amended or changed? SE is not the same for public and non-profit organization as profit organizations since their success can be measured in terms of change in capital, market share, and competitiveness with other organizations in the same industry. According to (Bryson, 2004) for public and non-profit organization effective strategy must create public value at reasonable cost or serious consequences are likely to ensue. Increasingly, integrated use of human resources, information technology, and financial management are crucial elements of organizing, strengthening, protecting, and sustaining organizational capabilities for creating public value. There are four commonly referred SE techniques: Gap analysis; Strength, Weakness, Opportunity and Threats (SWOT) analysis; Political, Environmental, Social and Technological analysis and Benchmarking. SWOT analysis was chosen in this paper since the success of public and non-profit organizations as any other organization depends not only on the organization's internal quality (staff, economy or public relation) but on also on the surrounding environment (political interference, available fund or private sector). The primary aim of SP is to bring an organization into balance with the external environment and to maintain that balance over time (Sackett, Jones, Erdley, 2005). Organizations usually have multiple characteristics under SWOT. Choquet fuzzy integral (Choquet, 1953; Torra, Narukawa, 2004) can aggregate these characteristics in non-additive approach and analyze the proportion of these characteristics on the basis of an importance weight assigned by experts and how the organization is performing based on those characteristics.

The objective of this paper is to analyse the proposal of quantitatively evaluate strategy in public and non-profit organizations based on SWOT analysis, Sugeno  $\lambda$ -measure and Choquet fuzzy integral (CFI).

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## METHODS

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SWOT analysis is used to identify the strength, weakness, opportunity and threats that affect the success of an organization (Humphrey, 2005; Humphrey, 2012). Strength and weakness are most often viewed as internal factors while opportunity and threat are

considered external factors. Strength is what an organization has or what it can offer that others of its type do not. Weakness in opposite is what an organization does not have or does not offer others of its type do. Opportunities are advantages in the environment that an organization could use. Threats are situations in an organization's environment that could compromise the organization's success (Humphrey, 2005; Humphrey, 2012).

SWOT analysis can also be used for non-profit organizations, governmental units and for individuals for decision-making situation when a desired objective has been defined (Amin, Razmi, Zhang, 2011; Avny, 2007; Scolozzi et al., 2014)). SWOT sub characteristics and their priorities are highly dependent on the type of organization (Chang, Huang, 2006; Humphrey, 2005, Humphrey, 2012; Yuksel, Dagdeviren, 2007). The first step of the SWOT analysis is to identify characteristics and categorize them accordingly based on the objective of the organization. It should be noted that it is important to revise the original SWOT analysis from the strategic plan to see if the organization has exploit its opportunities overcome its weakness, or if it is facing new threats and so on, since the implementation of the plan. Then using expert opinion weight is assigned for each criterion.

SWOT analysis is used to identify the importance of sub characteristics in order to choose the best strategy for an organization. However, this practice does not provide analytical means to evaluate importance of characteristics. Some authors have proposed methods to quantify results of a SWOT analysis: Yuksel and Dagdeviren (2007) used analytic network process to develop an evaluation method for SWOT analysis. Chang and Huang (2006) discussed application of a quantification SWOT analytical method and Sevkli et al. (2012) applied fuzzy analytic network process.

Fuzzy integrals are interesting tools to summarize all the pieces of information provided by a function in a single value; this value could be a sort of average of the function, in terms of the underlying fuzzy measure. Fuzzy integrals permit the aggregation of information under different assumptions on the independence of the information sources. In particular, to model situations in which sources are independent as well as in situations in which such independence cannot be assured. Many authors have used fuzzy integrals, among these are: Yang (2012), measuring software product quality with ISO standards based on fuzzy logic technique. Authors in China have used fuzzy integrals for comprehensive framework for measuring the performance of an organization resource planning (Wei, Liou, Lee, 2008) and other researchers have used fuzzy integrals for handwritten signature verification (Singh et al., 2013) and many others (Torra, Narukawa, 2004; Verkeyn, Botteldooren, De Baets, 2011).

Fuzzy integrals use the term fuzzy measure, which does not require additive property. There are several aggregation operators in decision analysis, fuzzy measure is one of this aggregation methods that is used to integrate all values from individual subsets nonlinearly (Chang, Wu, Lin, 2008; Sugeno 1974).

Fuzzy integrals are integrals of a real function with respect to a fuzzy measure, by analogy with Lebesgue integral which is defined with respect to an ordinary (i.e. additive) measure. There are several definitions of fuzzy integrals, among which the most representatives are those of Sugeno Integral (Sugeno 1974) and CFI (Choquet 1953). The CFI was chosen over Sugeno integral for this paper since the Sugeno integral is based on

max and min, the min max integral calculation can only determine interval at which the measured values are possibly located, unlike the CFI, which provides a unique solution.

CFI is a fuzzy integral based on fuzzy measures that provides alternative nonlinear computational scheme for aggregating input information unlike other fuzzy models. Choquet integral is used in multiple criteria decision-making problems where the decision criteria are interactive (Yang, 2012; Singh et al., 2013).

## RESULTS

The tables below (Table 1 to Table 4) contain SWOT analysis characteristics of Prague, as the result of the update 2004-2008 (Strategy, 2008). The document (Strategy, 2008) contains seven categories of SWOT analysis, one characteristic was chosen from the categories that could be used to evaluate activities of the municipality of the city. These categories include infrastructure, safety and security, city resilience and city management and administration. However, the results of the analysis would more precisely reflect the performance of the city if performed on the SWOT analysis of each category.

The weight and performance were assigned by five experts from different fields of public administration familiar with strategic planning, urban planning, social studies and regional economy.

Weight is the importance of the characteristics for the success of the city on the scale 0 to 1. The third column (Table 1 to Table 4) is the current performance of the city on the listed characteristics the value for the performances were collected using linguistic variables. The linguistic variables from the performance column were presented using trapezoidal membership function (Fig. 1).

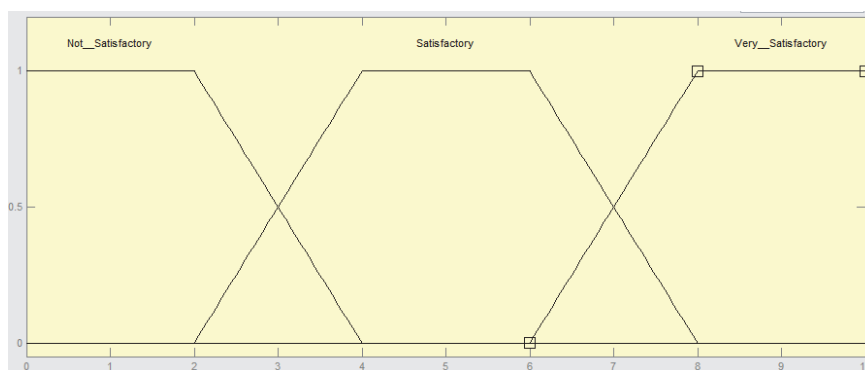


Figure 1: Trapezoidal membership function of fuzzy sets for linguistic variables

Determining membership function is highly subjective on what is not acceptable, acceptable and very good performance for a specific organization. In this paper, the membership function was chosen by expert opinion. If the city's performance on a characteristic is less than or equal to 2 out of 10 then it is completely unacceptable (not satisfactory) and above 2 to 4 is not satisfactory but with degree less than 1. If the performance is between 2 and 8 it is satisfactory with degree. Performance between 8 and 10 is very satisfactory with a complete belonging to the set. Then Yager's ranking indices



were used to transform performance to crisp values (Isabels, Uthra, 2012). The same membership functions were used for Weakness, Opportunity and Threat.

Table 1: Characteristics SWOT analysis of Prague – part Strength

Characteristics	Weight	Performance	$\lambda$
Sufficient capacity of elementary and secondary educational facilities	0.57	5.5	-0.989
Well-functioning public transport system	0.82	9.5	
Implementation of comprehensive flood protection systems	0.50	5.5	
Gradual renewal and development of energy networks	0.54	1.5	
Size and strength of the city economy	0.58	5.5	

Based on the evaluation of experts sufficient capacity of elementary and secondary educational facilities has 0.57 importance out of 1 and currently the city has satisfactory capacity. Prague has a very well-functioning public transport system (8, is very satisfactory) which experts believe is very important to the success of the city (0.82). The fourth characteristic, gradual renewal and development of energy networks has 0.54 importance but the city's performance to on the gradual renewal and development of energy networks is not satisfactory.

Other characteristics of SWOT analysis (means Weakness, Opportunity and Threats), are defined by the same way as Table 1, are in Table 2, 3 and 4.

Table 2: Characteristics SWOT analysis of Prague – part Weakness

Characteristics	Weight	Performance	$\lambda$
Poor coordination with public sector	0.58	5.5	-0.971
Weak crime fighting and drug protection	0.58	1.5	
Hypertrophied and complicated system of public administration	0.48	5.5	
Ineffective utilization of housing fund	0.54	5.5	
Insufficient effectiveness and, consequently, lower capacity of the central wastewater treatment plant	0.50	5.5	

Table 3: Characteristics SWOT analysis of Prague – part Opportunity

Characteristics	Weight	Performance	$\lambda$
Support from European Union	0.46	5.5	-0.980
Position heart of Europe	0.44	5.5	
Well-developed and diverse telecommunications networks suitable for multimedia communication	0.50	5.5	
Greater range of tourist destinations within and outside Prague's Heritage Conservation Area of the city	0.48	1.5	
Balanced social structure	0.76	1.5	

Support from the European Union has 0.46 importance for the improvement of Prague city and being the centre of Europe has 0.44 importance for the success of the city. Of the listed characteristics, balanced social structure has the highest importance but currently the city does not have satisfactory balanced social structure. The importance of well-developed and diverse telecommunications networks suitable for multimedia communication for the success of the city is 0.50 and the current telecommunication network available in the city is satisfactory.

Table 4: SWOT analysis of characteristics of Prague – part Threats

Characteristics	Weight	Performance	$\lambda$
Loss of citizens interest for public affair	0.58	5.5	-0.985
Competition of other cities	0.56	1.5	
Loss of Prague's international standing as a unique heritage site	0.42	5.5	
Lack of financial resources for the development of modern educational programs and comprehensive social services	0.62	5.5	
Growing xenophobia and expression of racism and extremism	0.74	5.5	

## DISCUSSION AND CONCLUSION

As mentioned above due to time constraint only one characteristic from the chosen categories were included in the analysis therefore the numbers shown on the result here are focused on general objective and goal. The city has more Strength, weakness, opportunity and threats.

The aggregated quantized SWOT analysis was calculated based on the evaluation of experts, using Sugeno  $\lambda$ -measure and CFI. The numbers in the following table (Table 5) show how strong is Prague city's strength, how weak is its weakness, how effective are the opportunities at the city's disposal and how well are they being exploited and how bad is the Threat the city is facing and how eminent it is. Small percentage result for strength could happen for two reasons; if importance of the characteristics the city administration considered as the strength are not very important or the characteristics the city consider as strength are not that strong meaning the city is not performing on the characteristics as well as the administration believed. Acceptable Strength, weakness, opportunity or threat is subjective, depends on different factors such as economy of the city, region, history and so on.

Table 5: Evaluation value for S,W, O and T (in %)

Strength	Weakness	Opportunity	Threat
87.53	53.84	49.31	54.53

Based on the result from the above table the strength of the city is 87.53% where the perfect record is 100%. The city has more strength than weakness 53.84%. The city is currently exploiting opportunities 49.31% and is facing a threat 54.53% that affects the success of the city in a perfect world the city should be facing zero threats. Lack of financial resources for the development of modern educational programs and comprehensive social services and Growing xenophobia and expression of racism and extremism in the threat table have 0.62 and 0.74 out of 1, which is the reason that the aggregated threat is significant in the evaluation table (table 5).

To improve the success of the city the authorities have to consider utilizing their opportunities more and focus on strengthening their weaknesses with higher priority. These methods could also be used to compare alternative strategies.

The example mentioned above proves the possibility of using Choquet fuzzy integral for the decision making on the level of the municipality. Although the final decision is always the political municipality board, the method presented in this paper would provide

to the board the optimized opinion of the wide range of experts involved in the city development. The presented example is based on the relatively narrow range of experts but the wider range would provide even more specialized numbers and opinions related to the city's development. This could help to improve handling sources within the city and to improve the city management focused to the quality of life of inhabitants.

The opinion of experts on the weight of characteristics could differ based on their fields. In the future fuzzy measures could be used to weigh the opinion of each expert for each characteristic to increase the quality of the analysis.

The methodology presented in this paper is not the only one available for the evaluation of strategic plans or their parts. Reference Framework for Sustainable Cities (RFSC) is another tool that could be used for the evaluation of the strategic plans of cities on the basis of sustainable development (RFSC, 2011; RFSC, 2012). It means that RFSC analyses the four areas simultaneously: economy, social, environment and governance. The acronym 'RFSC' can be interpreted as Respect, Flexibility, Support and Cooperation (RFSC, 2016) where for 'respect' the RFSC values the diversity of European cities, respecting differences in local priorities and institutions. RFSC enables cities to move at their own pace and choose the scope of their involvement. The RFSC is used in countries such as CR, France, Italy, Netherlands, Poland, Portugal, Spain, Sweden etc. (RFSC, 2016a)

The result of SWOT analysis using the proposed method in this paper could be used as an input for the RFSC i.e. by conducting SWOT analysis using Sugeno  $\lambda$ -measure and CFI researchers could get a clear analytical analysis of a city's performance on economy, social, environment and governance issues.

## ACKNOWLEDGEMENTS

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This article was supported by the projects No. SGS\_2016\_023 of the Ministry of Education, Youth and Sports of CR with title 'Economic and social development in private and public sector' at the Faculty of Economics and Administration, University of Pardubice.

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# Data Formats for Storing Knowledge in Conversational Algorithms

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## **Abstract**

*The conversational algorithms or so-called “chatbots” have been significantly presented in the field of information science since 1964. The first coherent conversational algorithm with competence in fully interactive communication with the human being was discovered within that period of time. It was designed by Joseph Weizenbaum and named ELIZA. Our paper is aimed to analyse existing ways of solving these problems and to assess their functionality first. Then the testing and summarizing of each individual implementation based on AIML follows for the purpose of selecting the optimal technological platform for implementation of the conversational agent. Finally, coming out of the findings, we evaluate the potential of this field of AI with regard to the application in practice during the particular next years.*

## **Keywords**

*Chatbot. Eliza. MegaHal. Alice. Conversational Algorithm.*

## **INTRODUCTION**

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The first integrated algorithm capable of complex interactive communication with the human being was the algorithm ELIZA (Lokman, Zain, 2010). The main problem of this algorithm is its inability to accept and solve situations without the unequivocal response or with the multiplicity of responses. The close connection between the keyword or a pair of keywords in the sentence input and the resulting response is the next significant problem. Despite of that, ELIZA has been the inspiration for lots of other researchers. Richard Wallace is one of the most successful experts on this field at present. His algorithm A.L.I.C.E.(Artificial Linguistic Internet Computer Entity), in short Alice, represents quite sophisticated solution. Inspired by the algorithm ELIZA the development of Alice started on 23 November 1995. That more innovative outcome has been constantly developed since 1995 (Wallace, 2015). During its existence Alice won Loebner's prize for several times, in fact in 2000, 2001 and 2004 (loebner.net, 2015). Despite its existence as the current problem solved item with the great potential of the applicability, there exist a few more conversational algorithms not based on ELIZA philosophy. From a number of them MegaHal (Hutchens, 2015) is worthy of mentioning. It was publicly introduced for the first time in 1998 on the Loebner's prize contest. Contrary to the static way of answering used by all algorithms based on Eliza, MegaHal uses Markov's models (Hutchens, 2015) as the distinctive difference from the other practically used ways of solving this problem.

The subject of this paper is the summary of the main practically applicable solutions in the field of conversational algorithms as well as the prediction of the future tendencies of this branch of computer science from the view of its aplicability. The fundamental for stating its future trends will be the result of conducted test being aimed at the data storing technics and the manipulations with these findings.

Syntactic and semantic ambiguity of the user's input and insufficient computing power of current software and hardware resources appear to be the relevant problems in the attempts to implement any algorithm into the authentic conversation with a client. To solve the first problem we can create a compiler, that would be able to absorb the rules of our language, but its implementation is unreachable because of hardware and software limits (Schumaker et al, 2007).

It is also necessary to realize, that if we were able to resolve these problems and we had the mechanism that would be capable of reading the user's input in the real time and processing it into the usable form through the lexical, syntactic and semantic analyses, we would still encounter the next limitation – the inadequate set of responses. Our aim here is to refer mainly to the fact that the most advanced computing and data storing mechanism, the human brain, requires exercising and drilling as well. It takes several years of everyday conversational interactions, while a person as an individual can express some limited palette of conversational topics. It is therefore necessary to focus not only on the mechanism of processing the user's input and selection of the correct answer, as Alice algorithm does, but also on teaching the system based on the previous conversational interactions as it does MegaHAL algorithm.

## **RELATED WORK**

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The first coherent conversational algorithm with competence in fully interactive communication with the human being was Eliza. It is a simple conversational algorithm composed by Joseph Weizenbaum. It was built between 1964 and 1966. The basic idea of the algorithm has been to create a psychotherapist, whose task is to identify the patient's problem and diagnose it properly. The algorithm works on the basis of the so-called "pattern matching". The first implementations of the algorithm simply replaced the keywords of the input. For example, in response to the applied entry: "I have a headache" the congruent answer might be: "Why do you have a headache?" (Weizenbaum, 1966). This method of obtaining the answer to the individual questions can be seen in the large number of the other, much more sophisticated algorithms. Due to its simplicity Eliza has an advantage in comparison with the more advanced competitors. Operation of Eliza algorithm implementation is really simple. Just maintaining of continuity in addition of the association rule: keyword / response. The problem of operation in that way is a huge number of manually entered data as well as a very small overview of existing knowledge. Eliza works on the patterns and their identification. That means the responses are given in advance and in case that the answer is not included the general questions follow being applicable to the most conversational blind alleys and acquire another interaction from the user. Eliza algorithm has a relatively straightforward way of identification of keywords (Fig. 1). Consequently, the answer depends on the initial set up of constant, in this case P constant, which determines the relevance of the corresponding answers.

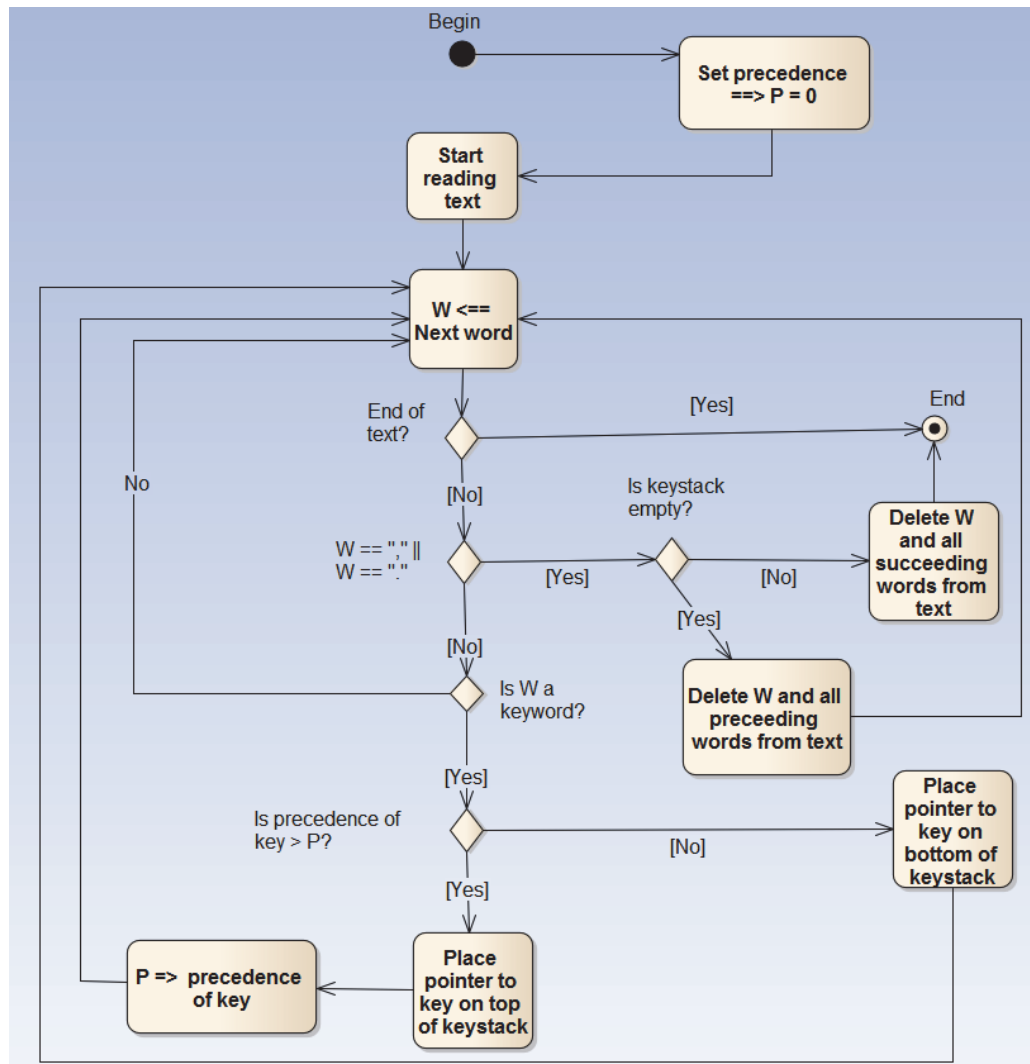


Fig. 1 Identification of keywords in Eliza.

Second conversational algorithm Alice is set on the processing of natural human language. Its author is Richard Wallace and it was launched in public on 23 November 1995. The Alice algorithm accesses into conversation with the user by applying of the heuristic pattern matching techniques. The algorithm was inspired by the already mentioned one, Eliza. Despite the relatively advanced concept of the algorithm its practical implementations were incapable of passing the Turing's test. All Alice's implementations work just like Eliza's ones to identify the pre-built patterns. The difference is that Alice uses AIML (Artificial Intelligence Markup Language). The advantage of this technology is a wide range of predefined conversation topics, allowing the conversational robot to simulate the human being plausibly (Wallace, 2015). AIML is a language based on XML, designed just for making conversational robots. Its syntactic marking includes some basic XML tags: Category – categories in AIML are the fundamental units of knowledge containing at least two other tags: a pattern and a template (Ringate, 2001).



```
<category>
  <pattern>AKO SA VOLÁŠ</pattern>
  <template>Moje meno je Alice</template>
</category>
```

Fig. 2 Demonstration of the knowledge unit in AIML.

In elementary cases the knowledge unit can be characterized as a pattern of questions and the corresponding answers (Fig. 2). Pattern – the entered tag represents one or more user's inputs to which the chatbot is able to answer pertinently. In AIML as well as in Alice the questions are presented either in the integrated static form as shown in Figure 2 or they might contain a special indicator \*, which represents any further unspecified set of indicators. The content of the figure (Fig. 2) can be the corresponding example for the first possibility. Secondly the request could be defined as follows: „AKO SA \*“. However, this way the answer: „Moje meno je Alice“ might be assigned to the question: „AKO SA MÁŠ“ as well. So it is necessary to be cautious in case that you use this method of declaration. Template – tag represents the return value for a particular question or pattern located in the tag pattern.

```
<category>
  <pattern>AKO SA VOLÁŠ</pattern>
  <template><![CDATA[Volám sa <bot name="name"/>.]]></template>
</category>
<category>
  <pattern>AKO ĽA VOLAJÚ</pattern>
  <template>
    <srai>ako sa voláš</srai>
  </template>
</category>
```

Fig. 3 The sample of application of the complex knowledge structures in AIML.

The implementation of the knowledge unit using variables and redirections is illustrated in figure 3. The question „AKO SA VOLÁŠ“ according to the given definition of tag template would be responded with the answer: "Moje meno je" followed by a variable name representing the chatbot. In the case of the user's questioning: "Ako ťa volajú", the content of the tag template in category of the tag pattern with a string „ what is your name“ would be the answer. The new tag srai is used there, as you can see, for redirection to another defined unit of knowledge. It ought to be reminded that it is only a sample of the basic principle of operation of the algorithm Alice based on AIML. The comprehensive documentation and all the signs of a given language can be found on the official website.

The third algorithm MegaHal was introduced for the first time through the implementation of the same name in the contest for Loebner's prize in 1998. Its author is Jason Hutchens (Goertzel, Bugaj, 2006). It should be noted that in contrast of the previous two algorithms MegaHAL is completely useless in practice. It is caused by a number of its limits, such as the inability to have the correct word order to create responses by substitution. However, the interesting thing about this algorithm is its competence in learning from earlier conversations and therefore it has a disproportionately greater ability to develop itself than the chatbots based on AIML whose knowledge base is fixed and expandable only manually. MegaHAL is able to construct a language model based on previous interactions with its communicator. At the beginning the text of user's input is converted into lemmas provided that the word have to be a sequence of alphanumeric

symbols. This process ensures that the robot can not only memorize new words but also their context within a sentence. If the user has certain conversational habits MegaHAL will take them over automatically. The resulting string of characters is used for exercising of two Markov's models of the fourth order. One of these models can assume following symbol after any combination of four characters, while another one can predict preceding symbol of such a sequence. Markov's model expresses its forecasts in the form of distribution the probabilities over the all known symbols and consequently it is capable of sorting probable words from unlikely ones. MegaHAL attempts to generate relevant responses relying on one or more keywords from the user's input. This explains the need for two Markov's models. The first model generates the sentence from the keyword phrase, while the second model generates the rest of the sentence from the keyword towards the beginning of a sentence. Keywords are received from the user's input. The words contained in the sentence frequently such as conjunctions "a", "alebo", "že" and likewise are deleted because of the lack of necessity to place them into the response again. The rest of words are either retained or transformed, for example: "ja" - "ty" or "moje" - "tvoje". This algorithm is able to generate hundreds of candidates that could satisfy the conditions of the answers due to their relevancy. Therefore, the selection of the correct answer among the candidates is made through the formula (1):

$$l(w|s) = -\log_2 P(w|s), \quad (1)$$

where  $l$  is the information value and  $P(w|s)$  is the probability of word  $w$  followed by a sequence of symbols  $s$  based on Markov's model. MegaHAL selects the answer with the highest information value ( $I$ ) for given keywords.

The whole algorithm could be specified in four cyclically repeating steps:

1. Read the user's input, and segment it into an alternating sequence of words and non-words.
2. Select an array of keywords from this sequence and use it to generate a number of candidates for replying.
3. Display the reply with the highest information value to the user.
4. Use the user's input to update the Markov's models, so that MegaHAL can learn from what the user has typed.

Repeating of these steps ensures the chatbot's ability to learn new words and sequence of words based on the user's interaction. But it is also clear that the algorithm is unable to converse with the user unless it passes either a sufficient number of interactions or any different artificial training.

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## SELECTION OF A DATA FORMAT FOR STORING KNOWLEDGE

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Based on the entire conception of presented variety of algorithms as well as the identified risks it might be supposed that a significant shift in the application of robots in conversational practice is a way of storing knowledge of the robot during the learning process and subsequent selection of these skills in the specific input by the user. Actual implementations of AIML are put into practice through XML. This structure itself provides all the functional elements necessary for the proper and efficient operation of the conversational robot. The problem is the lack of flexibility in its expansion. In case that we

would like to add any new knowledge to the relevant robot, there is the need for creating a new XML file format, defining knowledge in the AIML format and then inserting the corresponding source code into the resulting file. Working with such a database is quite demanding and in view of system resources it is inefficient. Therefore, the possibility of using some of the relational databases that are in terms of data manipulation better adapted than static files is offered quite naturally. If we opt for data storage in this manner, despite the maintenance of the rules AIML we will encounter a problem with the flexibility of the solution quickly. As well as with XML the relational database schema is the fixed data structure only with limited modifications in real time. For these reasons the most appropriate candidate is the data format with the ability to define connections with AIML and would not having so strict structural rules. The storing of knowledge in JSON seems to be a suitable solution (Hill et al, 2015). Due to this format, we acquire problem-free control of each component knowledge by working with objects or fields without being limited with the fixed structure. Currently, there are several NoSQL databases that store their data this way. The quite popular MongoDB is one of the solutions. It is necessary to realize at the same time that the process of robotic conversation with a person is divided into sequences. The user enters his input, the robot takes the input and processes it according to a predefined algorithm. Subsequently, based on another algorithm it selects a specific answer or set of possible answers. Being able to define different topics of conversations we would manage to turn the whole process from synchronous to asynchronous and thereby reduce system load and the time needed to select answers. NodeJS is an ideal platform for systems based on asynchronous calls.

### Test for verifying the suitability of the data format

Based on the conception mentioned above, we have conducted a test resulting with the declaration about the accuracy of application of NodeJS with the data base on principles of JSON. The test was compounded from the implementation of Alice (AIML) in PHP and MySQL (Program O), Java and MySQL (Program D) as well as a prototypical implementation of the algorithm in NodeJS and MongoDB. The Server was equipped as follows: Intel Core i7-3601QM 2.30 GHz, 8 GB of DDR3 RAM, the Samsung SSD 840 Pro, Windows 7 Home Premium. Server designed for agent of Program O in the language PHP was composed of the following components: Apache HTTP Server 2.4.9, PHP 5.5.9 as a server module, MySQL 5.6.17. Server designed for agent of Program D in the language Java consisted of these components: Apache Tomcat 7.0.57, JVM 1.7.0\_71-b14, Java 7 Update 71, MySQL 5.6.17. Server designed for agent in the language NodeJS was composed of the following components: 4.1.2 NodeJS, MongoDB 3.1.

With regard to the different approaches of the different platforms, it is not possible to specify a single server configuration, although the configuration of the server components was unified within the options provided. The test was conducted through an Apache Benchmark, and 1000 queries were sent for every application through five parallel streams. All implementations had stored the knowledge unit defined as follows (Fig. 4).

```
<category>
  <pattern>Hi, how are you?</pattern>
  <template>Great, thank you for asking.</template>
</category>
```

Fig. 4 The knowledge unit used for test in AIML.

The question in the form "Hi, how are you?" has been the parameter sent while the resulting answer has been expected in the form: "Great, thank you for asking." A similar form has been also used in a JSON representation of the knowledge unit. The test has been performed 10 times in a row at intervals of 5 seconds. The data in the table are given in seconds. It emerged that within the conception of parallel processing selection of the pre-defined answers NodeJS combined with MongoDB is the fastest responding platform. However, this is just a trivial example of the AIML conception. We would be able to prove by the continuous incorporation of the proposed structure whether the findings are entirely consistent with the current data.

Table 1: Results of testing the agents' responses.

Test	PHP – Program O	Java – Program D	NodeJS – prototype
1	1,456000	0,940109	0,714302
2	1,511000	0,975622	0,741285
3	1,828000	1,180302	0,896802
4	1,589000	1,025985	0,779551
5	1,476000	0,953023	0,724114
6	2,260000	1,459236	1,108738
7	1,480000	0,955606	0,726076
8	2,031000	1,311375	0,996393
9	1,939000	1,251973	0,951258
10	1,442000	0,93107	0,707434
Avg	1,70	1,10	0,83

In the event of the specialized agent, let's say as a sales assistant, we can suppose the progress of conversation and so we can continue in parallel processing of the user's input as well as selecting a subset of responses coming from the topic of conversation. Consequently, above this set, we would select a particular response or a subset of responses for the matching input mode.

## RESULTS AND DISCUSSION

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It is clear from the test results (Table 1) that one of the major parameters, concretely the relevant time of the response of the agent to the user, is achievable through using the platform NodeJS. It also emerged from given test that the implementation of the algorithmic structures into this programming language does not differ from the implementation in any commonly recognized programming languages at all. Apart from the platform itself, the benefits of using JSON format for SQL have been quite clearly shown by that test. Due to the qualities provided by JSON, it is relatively easy to modify existing database without losing relational connections.

By means of the accomplishment of key elements of the component algorithms either in the analytical part of the work and from the test results we can prove that in case of practical implementation of the conversational agent is in terms of choice of a particular technological platform the most suitable candidate the pair NodeJS and MongoDB, and optimal design of the relevant agent is the coupling of the algorithms Alice and MegaHAL.

## **CONCLUSION**

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Based on the analysis of the functioning of the particular available conversational algorithms, on the assessment of their capabilities and shortcomings, it can be assumed that the conversational chatbots will have their practical application. We suppose for the main areas of practical use of the system such ones as online technical support, a sales assistant at online stores or widespread implementation of web section FAQ (Frequently Asked Questions) on any web page. In this case, however, a shift away from today's direction of the sector is necessary. The present tendency is about trying to create a chatbot able to "fool" the user and to pretend to be a human being in the way to be able to overcome the limits of the Turing's test, for example in the competition for Loebner's prize. Therefore, many algorithms such as Eliza use the general responses in the event of their inability to answer pertinently. Although they can partially satisfy the user and keep him in conversation, they fail in all ways to learn from the conversation and to prevent such a situation in the future. For that reason, it is necessary to stop focusing attention on the creation of the conversational robots that are more or less able to converse with the users on a wide variety of topics, but it is necessary to focus on the relevance and quality of responses to the specific topics. This could be achieved by combining already existing approaches. In the case of the right combination of AIML in connection with the selection of the answer to the given question as well as the ability to learn from the user by means of Markov's chains it is likely the conversational algorithm could remove both problems described at the beginning of this article. By means of using AIML the given robot would gain the mechanism for selection of responses as well as the relatively standard hardware and software equipment and due to the correct implementation of Markov's model, it would obtain the ability of self-improvement within every single conversation. In the aspect of being the robots with the predefined thematic focus, the set of the initial knowledge through AIML is limited and could be prepared in advance for the competent agent.

## **ACKNOWLEDGEMENT**

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This work was supported by the Slovak Research and Development Agency under the contract No. APVV-14-0336 and Scientific Grant Agency of the Ministry of Education of the Slovak Republic (ME SR) and of Slovak Academy of Sciences (SAS) under the contracts No. VEGA-1/0559/14.

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# Differences Among Knowledge and Normal Educational Texts: a fMRI Study

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## Abstract

*Knowledge texts are special kinds of educational texts created by methods of Knowledge Engineering and based on knowledge units as the representation of knowledge. In this paper, we concentrate to investigating the differences among normal and knowledge texts in processing by human brain. The objective is to reveal differences in human brain activity within working the texts and within recalling information and knowledge previously studied by the texts. Thus we invite 24 probands to undergo the experiment using the functional Magnetic Resonance Imaging (fMRI). We monitor and measure whether knowledge texts induce different brain activity compared to the normal ones. To eliminate the influence of prior knowledge to the recalling phase we use the texts on agriculture waste processing; the majority of the probands is not familiar with this branch. The results show that there is no statistically significant differences in the brain activity within reading (studying) the texts, but there is statistically significant differences in the brain activity within recalling knowledge - within answering dichotomous questions. In-depth analysis of data from the viewpoint of neuroscience is the subject of the further research.*

## Keywords

*Knowledge engineering. Knowledge text. Knowledge transfer. Magnetic resonance imaging.*

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## INTRODUCTION

In education, it is usual to receive feedback from the students on the quality of teaching approaches, study books, learning environment, etc. For this purpose, a spectrum of various methods is being used, e.g. questionnaire survey (Capay et al., 2011) or interactive elements in e-learning courses (Balogh et al., 2011). Our approach used in this work is different; we concentrate to an objective feedback from the students measured by brain activity within the learning process.

People were always interested in the function of the brain while processing the information. Trying to understand the processes in the brain has led the scientists to the



experiments that were often very complicated and difficult to realize. The refinement of technology in the past years has contributed to the advances in tools that provide a clearer picture to the understanding of what occurs in one's brain while they are performing a cognitive task, such as language production and comprehension.

Besides offering precise information about lesion sites in living patients, techniques such as neuroimaging (Positron Emission Tomography - PET, functional Magnetic Resonance Imaging - fMRI, near-infrared spectroscopy - NIRS) and electroencephalography (EEG) allow researchers to work with normal subjects when investigating brain processing and language-related tasks (Baretta et al., 2012). The cortical systems for language and action develop specific links between each other whenever actions correlate with specific language processes. From this, we can predict that whenever language and action information processing correlate with each other in the different cortical areas (Pulvermüller, 2005). Nowadays, new experiments can be based on the findings of the scientific disciplines that approach the process of human learning and describe reading activities through organ, cellular and molecular levels of brain activity – they are called neurosciences (Jindracek et al., 2014).

In recent years, the number of completed surveys using these methods is apparently increasing. Between them, the neurotechnologies represent relatively new and progressive class of approaches contributing to objective measurements in education. We can mention those where fMRI was used in narrative text reading experiments (Chow et al., 2008; Frieze et al., 2008), in text fragment reading experiments (Martin-Loeches et al., 2008; Speer et al., 2007) and other kind of text (Mashal et al., 2009).

The neurotechnologies or brain scanning techniques are more and more accessible for the purposes of pedagogical research. The price for an equipment of sufficient quality is decreasing which allows to make a fMRI experiments more available for university researchers (Horakova et al., 2015). In this paper we focus on functional Magnetic Resonance Imaging (fMRI) and its use in connection with the anticipated and planned research (Horakova et al., 2015).

The aim of the study is to conduct an experiment using functional Magnetic Resonance Imaging (fMRI), which will track the brain activity of students while reading various types of educational text fragments (normal form and knowledge form). This texts are prepared following the previous experiments done (Rauchova et al., 2014). We are interested in how cordial activation of the brain reflects working with two kinds of texts. The brain activity will be compared with the level of "baseline" i.e. string of letter "x". Not only the reading activity will be observed, but also the student's afford to retrieve the correct answers will be followed. This procedure is in accordance with the research design (Horakova et al., 2015).

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## **METHODS**

### **Knowledge and common educational texts**

Based on representing knowledge with knowledge units (Dömeová, Houška, Houšková Beránková, 2008), we can rewrite or write sentences, paragraphs or even longer text fragments in knowledge form according to methodology by Houška and Rauchová (2013). For instance and comparison Horáková, Houška, Luhanová (2015) shew the texts of several

sentences in a) normal (Sent A) and b) knowledge form (Sent B). They demonstrated these texts on a topic of agriculture waste processing (translated from Enviregion, 2014) used for analysing the technical differences among normal and knowledge texts in previous work (Horáková and Houška, (2014); Rauchová, Houška, Luhanová and Černíková (2014)). The same topic and text fragments were used for fMRI experiment as well.

## **Description of the experiment**

The experiment has had two phases – pilot experiment and standard experiment. The methodology of both phases of experiment was discussed with experts from Central European Institute of Technology Brno (CEITEC) and experiment was conducted there in the local laboratory as well. fMRI data were processed in two stages. In the first phase, data was processed the same sequence of steps for all probands.

The first stage was consisted of preprocessing and statistics on the individual level. Preprocessing included a fitting fMRI snapshots, correction of "slice timing correction", fitting an average fMRI snapshot and an anatomic snapshot into common stereotactic space and spatial filtering. Statistics on the individual level consisted of the settings of the linear model for task A and calculation of two effects (Sent A versus Baseline; Sent B versus Baseline) and settings of the linear model for task B and calculation of one effect (Sent B versus Sent A). The role of the task A was observing the brain activity in sections where the text has been displayed. The role of task B was observing the brain activity in sections 2 seconds before responding to the moment answer, i.e., a period in which there is a decision about a response. We have tested 3 research hypotheses: H1: The knowledge text (Sent B) in comparison with the string of text (baseline) statistically significantly different in the activation of brain regions. H2: The normal text (Sent A) in comparison with a string of text (baseline) is statistically significantly different in the activation of brain regions. H3: The knowledge text (Sent B) compared with the normal text (Sent A) just before decision about the truthfulness of the claim were statistically significantly different in the activation of brain regions. Group statistics have been conducted in the second stage. For task A and B statistics one-sample t-test have been used (Hastie, Tibshirani, Friedman, 2013), we have tested, in which brain regions effects significantly different from zero. Statistical level of significance was set at  $p < 0.05$ , and the results were taken into account multiple testing using FWE (Family wise error) correction. Moreover some other tests F test, t-test were used for testing the differences between knowledge and normal text for two variables "Accuracy" and "Time needed for decision about verity of statement" (Hastie, Tibshirani, Friedman, 2013).

## **Characteristics of probands**

After the discussion of our approach with the experts from CEITEC, who have carried out similar research successfully, we decided to work with 24 participants, the half was men and half was woman (i.e. 12 women and 12 men), that is less than expected. It is because we have used the maximum time when participants could be concentrated on the task. Each participant has been a right-hander to have comparable results, their age was between 18 and 37 years (age median was 23.9), that is very used age category for this type of experiment (Martin-Loeches et al., 2008). The chosen participants have been healthy students, because of the precondition for the ability to learn.

After the brain scan, participants have been asked to lie down motionless and to remember the maximum text fragments they could. After, the students have been asked to choose the correct answer (decision about verity of presented statement) by pressing the Yes/No button. The total time of the reading measurement was 22.5 minutes, the time for the answering part was 10 minutes. Moreover, the anatomical snapshots T1 MPAGE (with a resolution of 1 mm) have been captured.

## RESULTS

### Task A: Effect SentA vs Baseline

Colored areas (shown in red, yellow and orange) show brain regions where activity has been found to be higher when reading text Sent A than at baseline (strings of letters X). For depiction of the group Statistics of 24 probands see Figure 1. Table 1 shows the corresponding figures for the task mentioned above.

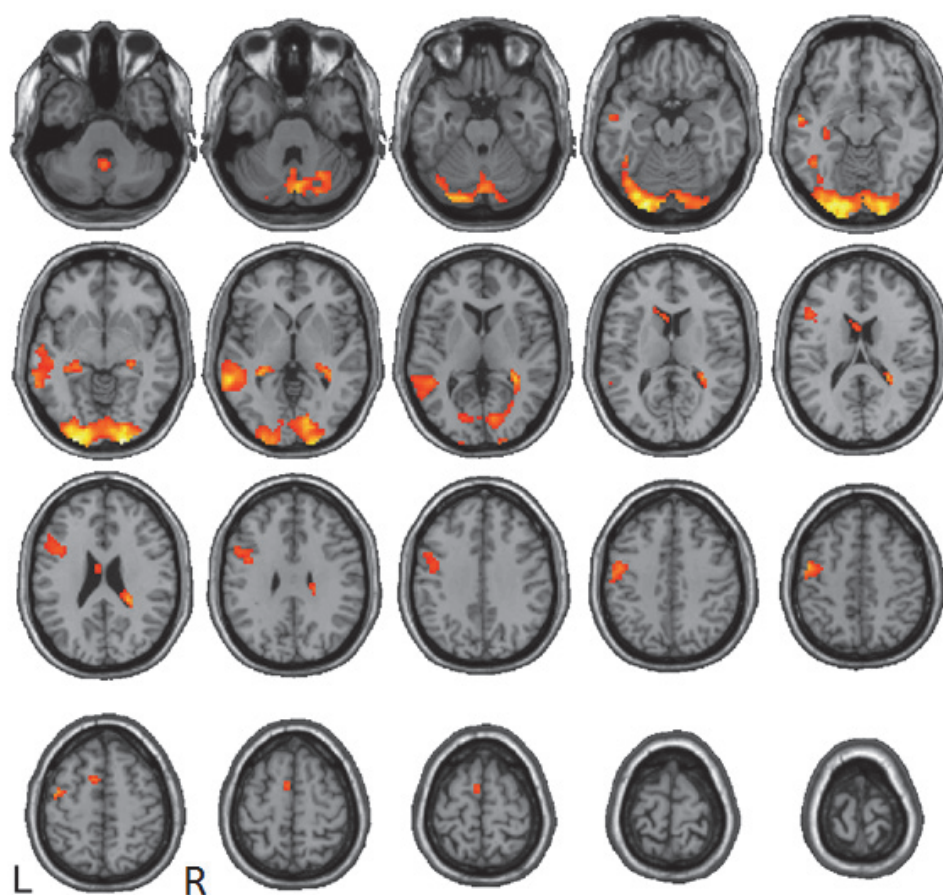


Figure 1: Illustration of Brain Areas activated for the task A: Sent A vs Baseline

Table 1: Group statistics for the task A: Sent A vs Baseline

Region	The Size of the Area [cm <sup>3</sup> ]	MNI Coordinates of the maximum	T – value in maximum peak
L/R occipital middle g; L/R calcarine; L/R lingual	41.8	21 -100 -8	13.18

g; L/R occipital inferior g; L fusiform g			
L temporal middle g; L temporal superior g;	9.3	-60 -43 1	8.37
L hippocampus	1.9	-30 -37 1	6.9
L precentral g; L postcentral g; L frontal inferior/middle g	7.75	-48 -4 49	6.82
L SMA	1.2	-9 8 55	5.41

L .. left; R .. right; g .. gyrus; SMA .. supplementary motor area

### Task A: Effect SentB vs Baseline

Colored areas (shown in red, yellow and orange) show brain regions where activity has been found to be higher when reading text Sent B than at baseline (strings of letters X). For depiction of the group Statistics of 24 probands see Figure 2. Table 2 shows the corresponding figures for the task mentioned above.

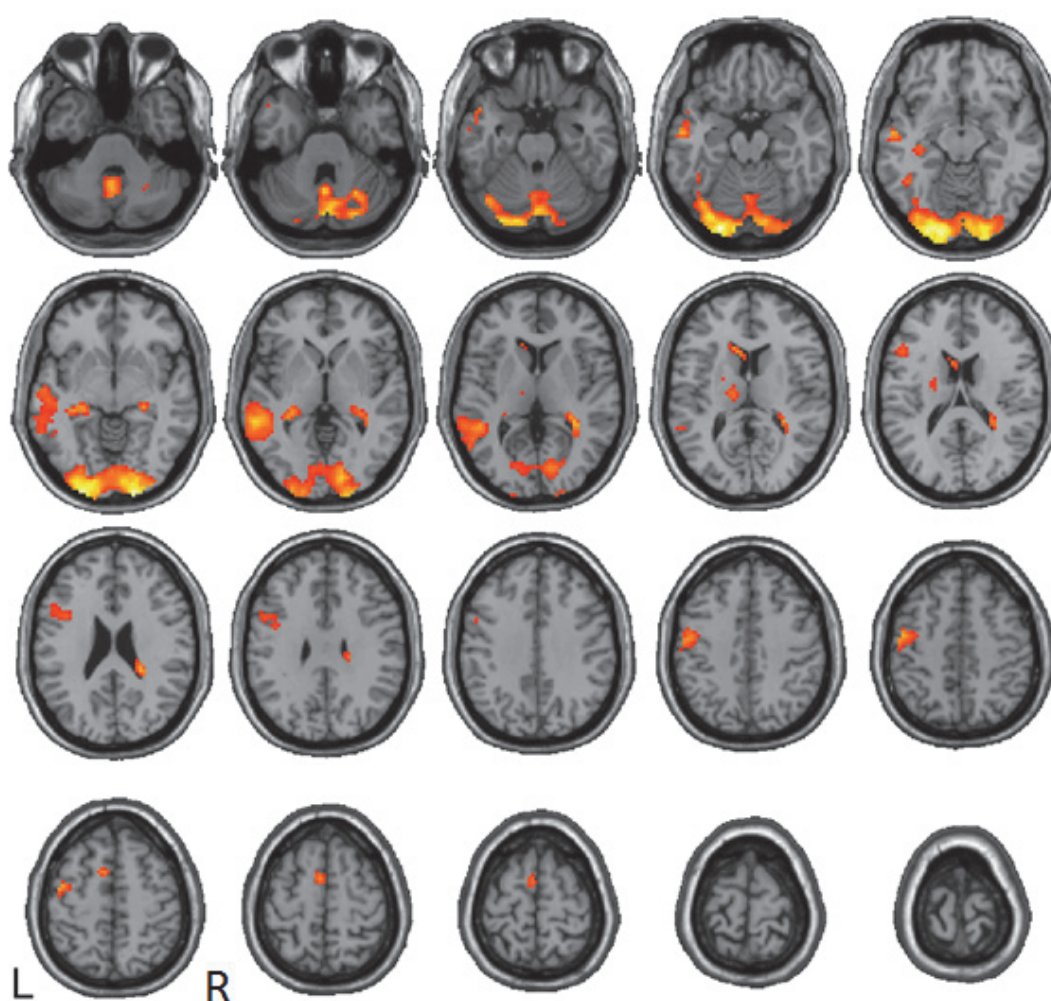


Figure 2: Illustration of brain areas activated for the task A: Sent B vs Baseline



Table 2: Group statistics for the task A: Sent B vs Baseline

Region	The Size of the Area [cm <sup>3</sup> ]	MNI Coordinates [mm] of the maximum	T – value in maximum peak
L/R occipital middle g; L/R calcarine; L/R lingual g; L/R occipital inferior g; L fusiform g	45.3	-24 -91 -17	12.88
L temporal middle g; L temporal superior g;	12.4	-60 -40 1	7.62
L precentral g	2.8	-48 -7 49	6.80
L hippocampus	2.3	-27 -28 -5	6.10
L SMA	1.5	-3 2 61	5.78
L frontal inferior g	2.5	-51 8 34	5.43
L thalamus	1.2	-12 -16 13	5.08

L .. left; R .. right; g .. gyrus; SMA .. supplementary motor area

### Task B: Effect SentB vs SentA

Colored areas (shown in yellow) show brain regions where activity has been found to be higher when responding the statement text Sent B than at text Sent A. For depiction of the group Statistics of 24 probands see Figure 3. Table 3 shows the corresponding figures for the task mentioned above.

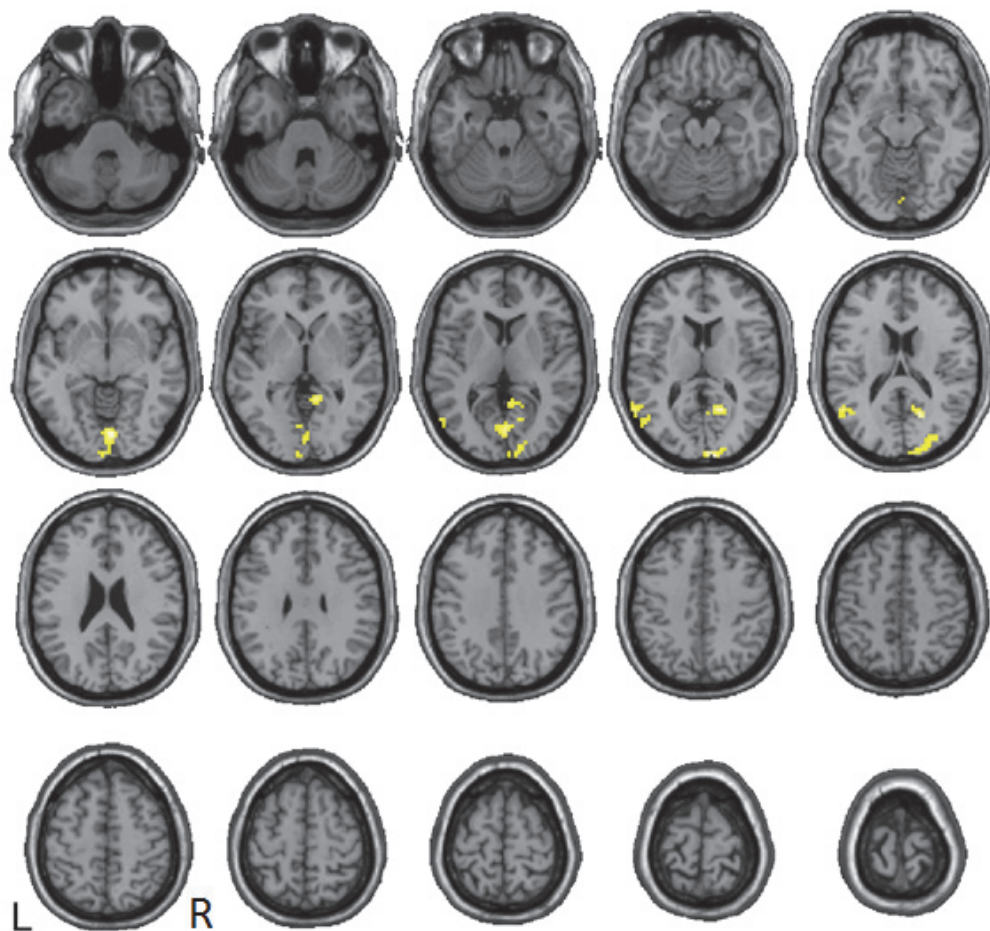


Figure 3: Illustration of brain areas activated for the task B: Sent A vs Sent B

Table 3: Group statistics for the task B: Sent B vs Sent A

Region	The Size of the Area [cm <sup>3</sup> ]	MNI Coordinates [mm] of the maximum	T – value in maximum peak
R occipital superior g; R cuneus	1.9	12 -100 16	5.37
R calcarine; R lingual g; R precuneus	2.2	18 -55 10	5.14
L calcarine; L/R lingual g	3.5	6 -82 -5	5.03
L temporeal superior/middle g	1.7	-54 -70 10	4.63

L .. left; R .. right; g .. gyrus

### Accuracy and time needed for decision about verity of statement

Moreover, we have measured the number of correctly recognized the truth of text fragments. Average number of correctly recognized the truth of fragments in style Sent A (common text fragment) was 14.867 and for Sent B (knowledge text fragment) was 16.267, p value for F test was 0.575 and p value for two- sample t test was 0.533 (level of significance  $\alpha = 0.05$ ). It means that variances are equal and means as well. However, we have measured average time needed for decision. Average time needed for decision about Sent A (common text fragment) was 8.555 sec and average time needed for decision about Sent B (knowledge text fragment) was 10.515 sec, p value for F test was 0.465 and p value for two- sample t test was 0.014 (level of significance  $\alpha = 0.05$ ). It means that variances are equal and means are not equal. Box plots for two above mentioned measuring are depicted at Figure 4 and Figure 5.

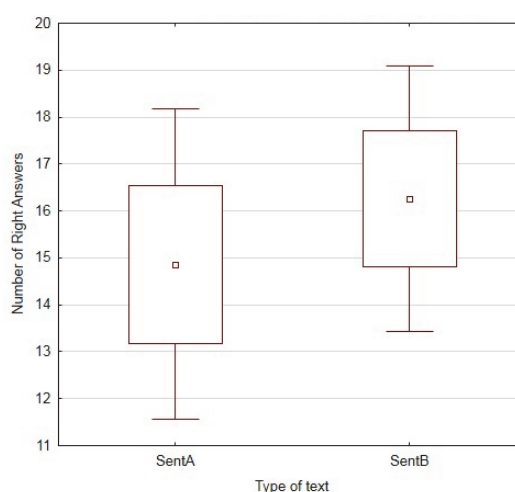


Figure 4: Box plots for number of right answers (correctly recognised the truth of text) according to 2 types of texts

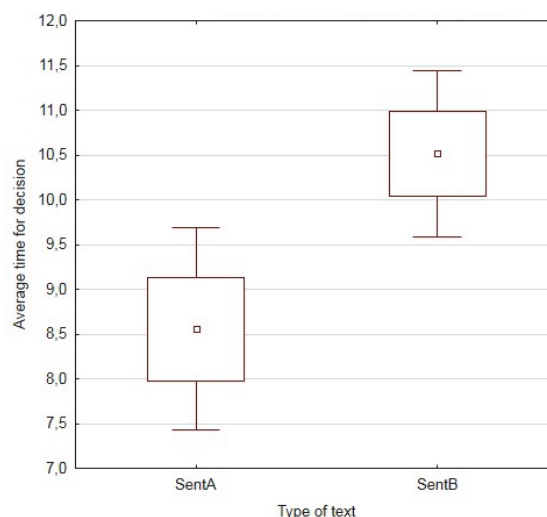


Figure 5: Box plots for average time for decision according to 2 types of texts

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## DISCUSSION AND CONCLUSION

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The experiment using functional magnetic resonance imaging shows that if probands read educational texts in normal form and texts in the knowledge form in comparison with baseline (a string of letters "x"), there are similar activations of brain areas implicated.

It was also identified areas where there is a higher activity just before a response to the opinion in the knowledge form (knowledge text) in comparison with the response to the statement in the normal form (normal text).

While watching the time needed to decide on the veracity of statements needed more time to text in the knowledge form in comparison with normal texts, which corresponds with the results Rauchová and Houška (2013), which found that the text reading knowledge needed more time.

When monitoring the accuracy of correct answers (determining the truthfulness of the claim) is that with the statements in the form of knowledge was more correct answers, but this difference was not statistically significant, which corresponds with the results by Rauchová and Houška (2013).

In the future research, it is necessary to focus on some other aspects potentially having an effect on brain activity when working with different types of text, such as gender impact (Chow et al, 2008), impact of prior knowledge (Molinari, 2015) of presented problem domain in text fragments, level of education Horáková, Houška, Luhanová, 2015), monitoring the impact of the level of short-term memory when reading the text (Frieese et al. 2008), the effect of specific learning disorders of probands. Beyond the dissemination of the results of other calculations of the effects of the above factors, it is intended to build on the experiment using additional imaging techniques, specifically using the method of eye tracking (Molinari, 2015), which can determine whether reading the same text fragments of knowledge and normal form as they used Horáková, Houška (2014) for the didactic analysis of the text leads to a different eye movements.

Based on these results it is possible to supplement the profile of the knowledge text (Horáková, Houška, Luhanová, Černíková, 2014) in terms of a new point of view.

## ACKNOWLEDGEMENT

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The paper is supported by the grant project of the Internal Grant Agency of the FEM CULS Prague "Determining the neuropsychological characteristics of learning for different kinds of educational texts using neurotechnologies", No. 20151047.

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# Automatic Evaluation of Machine Translation Output for Slovak Language

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## Abstract

*Future improvements of machine translation (MT) systems require reliable tools for automatic evaluation of machine translation system like tools for the identification and classification of machine translation errors. The aim of this paper is to summarise the metrics for automatic evaluation of machine translation systems and to propose a tool for automatic MT evaluation focusing on one translation direction, into Slovak language, that will be used in our project and in a dissertation thesis. We focus on a goal of the automatic MT evaluation; we describe the relevance of automatic evaluation of MT output in comparison to manual evaluation, basic methods for the automatic MT evaluation with the basic linguistic errors occurring frequently in the machine translation output. Our proposed tool for automatic MT evaluation comprises these methods and provides output data that can be used to improve existing machine translation systems like the Google translator API or the MT@EC, both are be used in our project.*

## Keywords

*Machine translation. Automatic evaluation of machine translation. Identification. Classification. Slovak language.*

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## INTRODUCTION

In the last decade Machine translation (MT) has become an important subject of the research not only in the academic field, but also in the commercial. From academic or research perspective, machine translation lets us apply and test various hypotheses in the field of linguistics, computer science and artificial intelligence. It allows us to discover the mechanisms and behaviour theories of languages using computer modelling and simulation (Minarik, Stastny, 2008; Skorpil, Stastny, 2008). Another reason for the interest of society for machine translation is its commercial applications. Nowadays, we live in a world, where over 7 billion people speak approximately 6000 languages. In the

"translation industry" consisting of more than 160 countries about 3150 translation agencies and 200000 freelance translators are been active. Often human translators are not able to produce fast translations, which are required for "dynamic" commercial or business communication between people speaking different languages. A second aspect of commercial interest in machine translation is the high cost of human translation and translation services. Human translator is able to translate about 10 pages per day (depending on the complexity of the source text), which sometimes causes a delay, for example when a new product is going to be launched on the market and so. The effect of this is the development and evolution of various translation tools and MT systems, which not only facilitate the work of the human translator, but MT helps with translating short texts of simple routine communication or repetitive texts (e.g. administrative texts or text messages).

Machine translation systems are competitive, which can be seen as a compromise between quality-cost-speed; they are not time consuming and financial demanding, but compared to human translation, they are in lower quality. Therefore, a question of the quality of MT output arises, the need of the evaluation of texts (output) generated by MT systems and for MT systems themselves. MT evaluation plays a key role in the field of machine translation. MT evaluation, namely the evaluation of MT systems is an essential stage to determine the effectiveness of the existing MT systems, but also to optimize their performances. Progress in machine translation depends on results of the evaluation (evaluation of MT quality) of new MT systems in order to show their better performances than the current. In this respect, questions about methods and criteria for the evaluation of MT quality remain.

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## RELATED WORK

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Although the manual evaluation is considered to be the most reliable method for MT evaluation, there are problems that it cannot cope with. Papineni et al. (2002) noted that the methods and metrics of manual evaluation are too slow and costly for development of MT systems. Fast feedback on the quality of the translation is important for progress of the system. Therefore, a considerable effort has been conducted to find the measures that correlate well with human judgments (Callison-Burch et al., 2009; 2010). Most of the work has been focused just on ranking the different MT systems, which is the first step towards their improvement, it does not provide enough scientific insights. Researchers (Popović and Burchardt, 2011) would often find it helpful to get the answers to the questions like *What is a particular strength/weakness of my system? What kind of errors does the system make most often? Does a particular modification improve some aspect of the system, even if it does not improve the overall score? etc.*

Based on Llitjós et al. (2005) classification scheme, Vilar et al. (2006) proposed a classification of MT errors together with a detailed analysis of the obtained results. The analysis with the classification have recently become widely used (Avramidis and Koehn, 2008; Max et al., 2008; Khalilov and Fonollosa, 2009; Munkova and Munk, 2014).

Popović et al. (2006) defined five error categories based on Vilar's et al. classification (2006) and presented the results for these categories obtained by human evaluators. They

also proposed a novel automatic tool based on Popović and Ney work (Popović and Ney, 2007).

## **AUTOMATIC EVALUATION METRICS FOR MACHINE TRANSLATION OUTPUT**

In order to make the evaluation more effective, researchers began to propose automatic methods for MT evaluation without human interaction. Series of automated translation quality assessment metrics have been proposed in order to reduce "time and labour" during the evaluation. They are usually based on measurements of similarities between translations, which is considered as a reference - human translation and a hypothesis or a candidate translation – MT output. Metrics of automatic MT evaluation can be based on statistical principles (n-grams or edit distance) or on deep linguistic structures (morphological, syntactic or semantic information).

### **Precision and Recall**

These measures belong among the easiest automatic evaluation measures. They are often used in natural language processing. They are based on matches- words in hypothesis with words in the reference translation (references), regardless of the position of the word in a sentence. They are opposite to each other, that means with increasing precision scores you may experiencing a decrease in recall score and vice versa.

$$precision = \frac{correct\ words}{length\ hypothesis} \quad (1)$$

$$recall = \frac{correct\ words}{length\ reference} \quad (2)$$

### **Position-independent Error Rate (PER)**

It is similar to recall measure. It is a certain degree of error rate, which means, it does not measure concordance, but difference.

$$PER = 1 - \frac{correct - \max(0, length\ hypothesis - length\ reference)}{length\ reference} \quad (3)$$

### **Word Error Rate (WER)**

WER rate was taken from the field of speech recognition. It is based on the edit distance and takes into account word order. The Edit distance or Levenshtein distance on word level is the minimum number of word insertions, substitutions and deletions necessary to transform the candidate translation into the reference translation.

$$WER(h, r) = \frac{\min_{e \in E(h, r)} (insertion(e) + deletion(e) + substitution(e))}{|r|}, \quad (4)$$

where *insertion* (*e*) – number of inserted words, *deletion* (*e*) – number of deleted words, *substitution* (*e*) – number of substitutions (in sequence or path *e*), *r* is reference translation of hypothesis *h* and  $\min_{e \in E(h, r)}$  is minimal sequence of word insertions, substitutions and deletions necessary to transform the hypothesis into the reference translation.

## Translation Error Rate (TER)

It belongs among the second-generation measures. In contrast to WER, shifts of blocks are allowed and counted as one edit with equal costs to insertions, deletions and substitutions of single words. The number of edit operations is divided by the average number of reference words.

$$TER(h, r) = \frac{\min_{e \in E(h, r)} (insertion(e) + deletion(e) + substitution(e) + shift(e))}{|r|}, \quad (5)$$

where *insertion* (*e*) – number of inserted words, *deletion* (*e*) – number of deleted words, *substitution* (*e*) – number of substitutions (in sequence or path *e*) and *shift* (*e*) – number of shifts of blocks, *r* is reference translation of hypothesis *h* and  $\min_{e \in E(h, r)}$  is minimal sequence of word insertions, substitutions and deletions necessary to transform the hypothesis into the reference translation.

## Cover Disjoint Error Rate (CDER)

CDER metric is a superset of the metrics WER, it is based on the Levenshtein distance. It does not add shift of blocks to its calculation but a long jump, because it does not penalize the shift of entire blocks. It uses the fact that the number of blocks in a sentence is the same as the number of gaps between them plus one. "Long jump" is equivalent to moving blocks while jumping refers to jump over the gap between the two blocks. These long jumps are also evaluated and read in sequence one after the other in a sentence. Long jumps are combined with the other steps of editing (insertion, substitution, and deletion) and with the null operation in case of identity.

$$CDER(h, r) = \frac{\min_{e \in E(h, r)} (insertion(e) + deletion(e) + substitution(e) + long\_jump(e))}{|r|}, \quad (6)$$

where *insertion* (*e*) – number of inserted words, *deletion* (*e*) – number of deleted words, *substitution* (*e*) – number of substitutions (in sequence or path *e*) and *long\_jump* (*e*) – number of long jumps, *r* is reference translation of hypothesis *h* and  $\min_{e \in E(h, r)}$  is minimal sequence of word insertions, substitutions and deletions necessary to transform the hypothesis into the reference translation.

## Human Translation Error Rate (HTER)

The disadvantage of both measures - TER and CDER is that they do not consider the possibility when a hypothesis is acceptable, but it is different than a reference. Therefore, currently the HTER measure is preferred, which depends on a fact that an editor is involved. The editor is used for post editing the hypothesis and a number of minimal necessary steps realized by editor for transformation of hypothesis to acceptable translation is counted. Finding the minimum number of steps in the transformation is often far more difficult task than actual human translation (it is more demanding to correct translated text than do the translation from scratch). This technique is used also in the DARPA evaluations.

$$HTER(h, pe) = \frac{\min_{e \in E(h, pe)} (insertion(e) + deletion(e) + substitution(e) + shift(e))}{|r|}, \quad (7)$$

where *insertion* (*e*) – number of inserted words, *deletion* (*e*) – number of deleted words, *substitution* (*e*) – number of substitutions (in sequence or path *e*) and *shift* (*e*) – number of

shifts of blocks,  $r$  is reference translation of hypothesis  $h$  and  $\min_{e \in E(h,r)}$  is minimal sequence of editor edits to transform the hypothesis into the acceptable translation.

For the purpose of our research, we decided to draw attention to the above-mentioned metrics and implement them in our tool for the evaluation of MT output. For this reason, we do not describe other metrics in this paper.

## ERROR CLASSIFICATION

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Error classification of MT output depends on multiple factors. These factors are the MT system itself, the content and language pair. There are several machine translation error classifications.

Popović and Burchardt (2011) defined the two main goals of the automatic method for error analysis and classification:

- to estimate the distribution of errors over the error classes in order to determine which error types are particularly problematic for a given translation system;
- to estimate the differences between the numbers of errors in each class for different translation outputs in order to compare translation systems.

We focus in our research on framework for human error analysis and error classification introduced by Vilar et al. (2006). Following error categories are defined:

- Missing word - a word that occurs as deletion in WER.
- Word order (reordering errors) - a word which occurs both in the reference and in the hypothesis, but not at the same position.
- Incorrect words: a) extra word - a word that occurs as insertion in WER, b) incorrect word form - an inflectional error (full form is not correct) or c) incorrect lexical choice - a word that disrupts the meaning.
- Unknown word.
- Punctuation.

## PROPOSED TOOL

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Our proposed tool for the MT evaluation is based on the idea of automatic errors detection. It will implement the described automatic evaluation metrics and detect five error classes (majority defined in Vilar et al., 2006): morphological errors, reordering errors, missing words, extra words and lexical errors. Our tool will be similar to tool Hjerson described by Popović (2011).

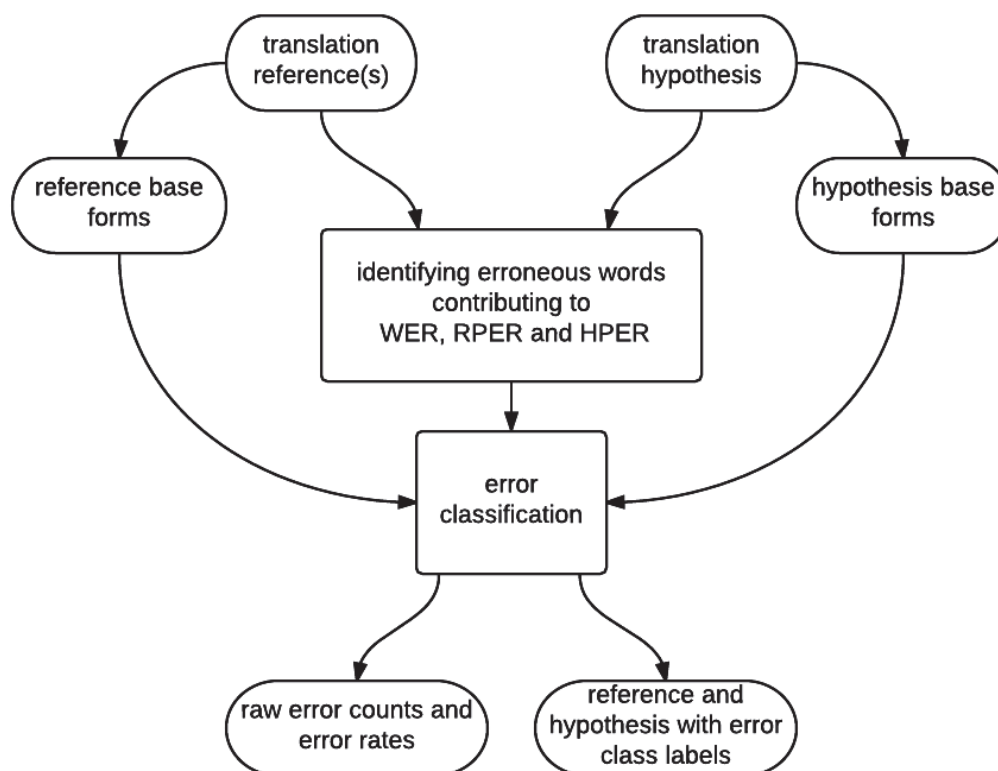


Figure 1: Workflow of the automatic error classification

The proposed tool will implement the edit distance algorithm (Levenshtein, 1966) and identify actual words contributing to the standard WER as well as to the recall/precision based Reference PER (RPER) and Hypothesis PER (HPER) (Popović and Ney, 2007).

Similar to Hjerson (Popović and Burchardt, 2011), the dynamic programming algorithm for WER will enable a simple and straightforward identification of each erroneous word, which actually contributes to WER. The RPER errors will be defined as the words in the reference, which do not appear in the hypothesis, and analogously, the HPER errors will be the words in the hypothesis, which do not appear in the reference. Once the WER, RPER and HPER errors will be identified, the base forms for each word will be added in order to perform error classification in the following way: inflectional error, reordering error, missing word, extra word and incorrect lexical choice.

Although the method is generally language-independent, we will focus on which error types cause a problem for a given machine translation system translating a text of various styles (administrative, scientific and publicistic) into inflectional language as Slovak. Therefore, we will try to optimize the algorithms to work well with inflectional languages used in translation outputs.

## CONCLUSION AND FUTURE DIRECTION

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The paper focused on the introduction of automatic evaluation of MT output and on the proposal of a tool for automatic MT evaluation that will be used in our work and in a dissertation thesis. We described most commonly used automatic evaluation measures for machine translation output: Precision and Recall, Position-independent Error Rate (PER), Word Error Rate (WER), Translation Error Rate (TER), Cover Disjoint Error Rate (CDER) and Human Translation Error Rate (HTER). By the text representation we arose from the transaction-sequence model which is described in (Munková, Munk and Vozár, 2013) and which was inspired by the work (Munk and Drlik, 2011; Munk et al., 2015). We also described error categories used for the classification of errors in MT outputs: morphological errors, reordering errors, missing words, extra words and lexical errors.

The proposed tool will be tested on one translation direction, from English or German language into Slovak language, which belongs to inflectional languages. We will optimize the algorithm based on first results and we will propose changes in the algorithm to make the tool more effective with the inflectional languages such Slovak or Czech language.

## ACKNOWLEDGEMENT

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This work was supported by the Slovak Research and Development Agency under the contract No. APVV-14-0336 and Scientific Grant Agency of the Ministry of Education of the Slovak Republic (ME SR) and of Slovak Academy of Sciences (SAS) under the contracts No. VEGA-1/0559/14.

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# Data Analysis of Seniors Computer Literacy

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## Abstract

*To outline the situation in area of seniors computer literacy in given sample of the population was the objective of this paper. More precisely, it deals with the level of a computer literacy of seniors and with classification this level on the basis monitored attributes. The data collection was realised on the basis cooperation with the senior centre and senior's clubs in city Pardubice. In total 407 seniors participated in this data survey. The data was evaluated in MS Excel and new output attribute based on the European Computer Driving Licence concept was created. The attribute represent a preparation of respondents to obtain the European Computer Driving Licence Certificate on the basis of computer skills. Seniors that do not use computer or notebook were discarded from the data set. The final data set included 252 seniors described by 29 attributes. Classification models were created in IBM SPSS Modeler on the basis new output attribute and selected inputs e.g. sociodemographic attributes, barriers in use of the Internet and purpose of computer use. Algorithms of decision trees as C5.0, CRT, CHAID, QUEST were chosen for solution of mentioned task. The best results of classification were achieved by C5.0 with boosting. The accuracy rate on the testing data set was 91.74%.*

## Keywords

*Senior. Data survey. Computer literacy. Evaluation. Classification model.*

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## INTRODUCTION

Very rapid development in the field of the computer science and informatics is a characteristic feature of present. It surrounds us all regardless of age. What is the knowledge of seniors in area of information technologies today? Do they use the new opportunities in this area and follow and use new trends? Or they are strange for them and they do not know how to use them? Would be their life easier? Are they able to cope with the younger generations in adaptivity to new things? The analysis of the computer literacy of seniors is the content of this paper.

The term of computer literacy or information literacy is defined for example in (Cole, Kelsey, 2004; Černá, Poulová, 2012; McMillan, 1996; Safar, Alkhezzi, 2006). The use of this term in social science is in (Lupo, Erlich, 2001), the list of digital skills is in (UK Digital, 2014), objectives in the computing literacy program are in (Dearborn, 1983) and the example of research questions is in (McNeil, 2006).

By (Cieslar, 2012) we can divide life phases into three basic groups: from 0 to 14 years; from 15 to 64 years; over 65 years. Life time of person is divided into different periodic scales. There is always taken into account the biological development that accompanies developing psyche. Then it is possible to create subgroups. These three groups may overlap. It is very individual how to divide the phase of life of a particular individual (Haškovcová, 2010; Janečková, 2010; Opatrný, 2007).

The education and training are now seen as a lifelong process. They are not limited to the period of childhood and youth. For example, University of the Third Age is part of lifelong learning. It gives seniors an education at the highest possible level. This kind of education brings more social and cultural development. There is also an initiative to educate in modern technology. It has to help seniors to live a full life in conjunction with today's society. That means, to know how to operate a computer, mobile phone, transportation systems, etc. An education of seniors is not just about increasing knowledge and skills, but about overall improvement in their quality of life (Dvořáčková, 2012; Ondráková, 2012; Straková, Veselý, 2013).

Among the main objectives of the Universities of the Third Age belongs to familiarize seniors with scientific knowledge, deepen their self-knowledge, gain certain perspective and facilitate their adaptation and orientation in the modern world. Other objectives are to meet generation and exchange of experience between them. University of the Third Age has also an important role in the field of the social contact. Social interaction for seniors represents: making contact with other seniors, overcome feeling of loneliness, uselessness, and deliberately slows the feeling of aging, maintaining mental freshness, convenience and quality leisure time (Dvořáčková, 2012; Ondráková, 2012).

The objectives of this paper are:

- To analyse the data from the survey about computer skills of seniors
- To outline the situation in area of computer literacy of seniors in given sample of the population based on classification model creation.

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## **METHODS**

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An international concept the European Computer Driving Licence (ECDL) deals with the computer literacy. This is known as International Computer Driving Licence in non-European countries. It establishes minimum knowledge and skills that are needed for effective and successful use of computers and software. It includes a wide scale training and certification programs. Among the main features ECDL according to (Kennedy, 2012) include: standardization, objectivity, independence, practicality, measurability.

The contribution of the whole concept lies in the fact that is internationally recognized, standardized, objective and independent way to verify the user computer skills through practice tests in different operating systems, commonly used applications, and

using conventional computers. Successful graduates are awarded a certificate regarding an international recognized qualification for computer work (ECDL, 2010), (Kennedy, 2012). A survey was used to determination of level of computer literacy of seniors. Selected questions were based on the ECDL concept.

Decision trees are chosen for solution of mentioned task. For example C5.0, CRT (Classification & Regression Trees), CHAID (Chi-square Automatic Interaction Detection) and QUEST (Quick, Unbiased, Efficient Statistical Tree) belong to among most widely known algorithms of decision trees (Maimon, Rokach, 2005). Decision trees are used to classify an object or an instance to a predefined set of classes based on their attributes values. These trees are frequently used in applied fields such as finance, marketing, engineering and medicine. They are useful as an exploratory technique. (Witten, Frank, 2005; Maimon, Rokach, 2005; Turban, 2005) Boosting is a general method for improving the performance of any learning algorithm (Maimon, Rokach, 2005). It can significantly improve the accuracy of a C5.0 model. For evaluation of achieved results common methods were used. In our case, it is possible to use e.g. accuracy rate AR (Witten, Frank, 2005; Han, Kamber, 2006).

## RESULTS

Cooperation with the senior centre and senior's clubs was used to the data collection. In Pardubice (it is the capital city of the Pardubice Region) it is 27 senior's clubs (Pardubice a, 2015; Pardubice b, 2015). The data collection was realised in years 2013 and 2014. The data was collected through personal data collection with direct contact with the respondent. In formulation of questions, the emphasis was on the intelligibility and clarity. Answers to questions were made up of a combination of closed and semi-closed answers (O'Sullivan et al., 2008). Graphic form of the questionnaire was chosen with respect of the needs of seniors (e.g. larger font size for easier reading). The questionnaire contained 28 questions (see Table 1).

Table 1: Description of questions

Q	Question/ Values of answers
q <sub>0</sub>	Object/ Respondent (senior): {1,2,...407}
q <sub>1</sub>	What is your sex?/ 1: man; 2: woman
q <sub>2</sub>	How old are you?/ Age categories 1: less than 65 years; 2: from 65 to 70 years; 3: from 71 to 75 years; 4: from 76 to 80 years; 5: more than 81 years (over 81)
q <sub>3</sub>	What is your marital status?/ 1: single; 2: married; 3: divorced; 4: widower/widow
q <sub>4</sub>	Are you still economically active?/ 1: yes, employed; 2: yes, self-employed; 3: no
q <sub>5</sub>	Your occupation was focused on area of ...?/ 1: administration; 2: technology (science, research); 3: manual labour; 4: management; 5: other
q <sub>6</sub>	What is your education?/ 1: primary 2: trained; 3: lower secondary; 4: secondary; 5: higher education; 6: university
q <sub>7</sub>	Do you use personal computer (PC, computer) or notebook?/ 1: yes; 2: no
q <sub>8</sub>	How often do you use computer?/ 1: no value; 2: very often; 3: once per week; 4: once per month; 5: I do not use it.
q <sub>9</sub>	Did you use computer in your occupation?/ 1: no value; 2: yes; 3: no
q <sub>10</sub>	For what purpose do you use your PC frequently?/ 1: no value; 2: use of text editors, spreadsheets, and graphic editors; 3: administrative work; 4: entertainment, games; 5: communication; 6: other

Q	Question/ Values of answers
q <sub>11</sub>	Can you imagine your life without PC?/ 1: no value; 2: yes; 3: no
q <sub>12</sub>	How often do you use the Internet?/ 1: no value; 2: very often; 3: once per week; 4: once per month; 5: I do not use it.
q <sub>13</sub>	What Internet services do you use the most?/ 1: no value; 2: retrieval of information; 3: Internet shopping; 4: e-banking; 5: other
q <sub>14</sub>	Which social network do you use to communication the most often?/ 1: no value; 2: ICQ, Miranda; 3: Skype; 4: Facebook; 5: Twitter; 6: other
q <sub>15</sub>	What is the most important positive of the Internet for you?/ 1: no value; 2: low costs; 3: easy manageability of the Internet; 4: quick information retrieval; 5: other
q <sub>16</sub>	What is the most important negative of Internet for you?/ 1: no value; 2: complicated manageability of the Internet; 3: incomprehensibility and disbelief to contents of the Internet; 4: occurrence of Internet advertisement; 5: other
q <sub>17</sub>	What prevents you to use the Internet more often?/ 1: no value; 2: lack of time; 3: concerns about security and privacy; 4: complicated accessibility of computer with connection to the Internet; 5: other
q <sub>18</sub>	For what do you use a text editor (e.g. MS Word, Writer) most often?/ 1: no value; 2: to writing of easy short texts; 3: to writing of extensive texts; 4: I do not use it; 5: other
q <sub>19</sub>	For what do you use a spreadsheets (e.g. MS Excel, Calc) most often?/ 1: no value; 2: creation of easy tables; 3: creation of graphs; 4: I do not use it; 5: other
q <sub>20</sub>	Can you create a presentation in e.g. MS PowerPoint, Impress?/ 1: no value; 2: I can do it alone; 3: I can do it with the help of another person; 4: I cannot do it; 5: I do not use it
q <sub>21</sub>	Can you work with a file manager (e.g. Windows Explorer, Total Commander)?/ 1: no value; 2: I work alone; 3: I work partially; 4: I work but with the help of another person; 5: I do not know it
q <sub>22</sub>	Are you owner of the ECDL certificate?/ 1: no value; 2: yes; 3: no
q <sub>23</sub>	Have you ever been on a computer course for seniors?/ 1: no value; 2: yes; 3: no
q <sub>24</sub>	What is your most common way of education in area of computers?/ 1: no value; 2: expert journals; 3: Internet; 4: educational course; 5: University of the 3th Age 6: private tutoring; 7: I do not educate; 8: other
q <sub>25</sub>	How do you care about the security of your computer?/ 1: no value; 2: I use applications by my needs (custom settings) 3: I set computer protection with the help of another person; 4: I use basic settings of the computer protection; 5: I do not know what is it; 6: other
q <sub>26</sub>	Would you like to improve your level of computer skills?/ 1: no value; 2: yes, I would like to improve the basic controls of the computer; 3: yes, I would like to learn about new programs; 4: yes, I would like to learn about new Internet services; 5: yes, I would like to learn new programming languages; 6: no, I am satisfied with my skills
q <sub>27</sub>	Do you understand the hardware?/ 1: no value; 2: yes; 3: no
q <sub>28</sub>	What digital technologies do you use?/ 1: no value; 2: smart phone with an Internet connection; 3: music players; 4: digital camera; 5: no digital technologies; 6: other

## Data Analysis

Total 407 respondents (229 women nad 178 men) took part in the survey. The obtained data was processed in MS Excel. Questions were divided into 4 groups:

- Group 1: Use of computer or notebook (q<sub>7</sub>) to the sociodemographic questions q<sub>1</sub>, q<sub>2</sub>, q<sub>5</sub> and q<sub>6</sub>
- Group 2: Barriers in use of the Internet (q<sub>17</sub>); the positive (q<sub>15</sub>) and negative (q<sub>16</sub>) of the Internet for respondents; and frequency to access to the Internet (q<sub>11</sub>) and use of computer (q<sub>8</sub>)
- Group 3: Purpose of computer use (q<sub>10</sub>); use services in the Internet (q<sub>13</sub>); use of social networks (q<sub>14</sub>); use of digital technologies (q<sub>28</sub>)

- Group 4: Ability to work with text editors (q<sub>18</sub>); spreadsheets (q<sub>19</sub>); file manager (q<sub>21</sub>); hardware (q<sub>27</sub>); and to do presentations in e.g. PowerPoint) (q<sub>20</sub>).

Group 1: Socio-demographic questions (indicators). The data analysis was focused on use of computer to the socio-demographic indicators as age, occupation and education firstly. Respondents by age are in Table 2. We can see, number of seniors using computer or notebook with age is decreasing. The opposite, phenomenon goes among respondents who do not use computer, i.e. with age, their number is growing. Number of respondents by occupation are in Figure 1. Respondents who worked in administration in the past formed the largest group using computer. Conversely, respondents who worked manually have the largest representation in the group that does not use computer or notebook. In terms of educational attainment, the most of respondents using computer (97 respondents) had completed secondary education. Respondents with academic education were the second most frequent category (87 respondents). Respondents with primary education using the computer (2 respondents) are in the smallest group.

Table 2: Use of computer (notebook)

Age group	Use of computer	
	Yes	No
less than 65 years	96 (23.59%)	9 (2.21%)
from 65 to 70 years	77 (18.92%)	6 (1.47%)
from 71 to 75 years	43 (10.57%)	41 (10.07)
from 76 to 80 years	31 (7.62%)	47 (11.55%)
81 years and more	5 (1.22%)	52 (12.78%)

Group 2: Positives, Negatives and Barriers in Use of the Internet. This next whole analysis deals only with respondents, that use computer (i.e. 252 seniors (61.92%)); from this number in total 170 (67.46%) seniors use computer very often; 59 (23.41%) once per week and 23 (9.12%) once per month. Majority of respondents (167; 66.23%) use the Internet very often and 58 respondents (23.02%) use it once per week.

Barriers in use of the Internet (q<sub>17</sub>); the most important positive (q<sub>15</sub>) and the most important negative (q<sub>16</sub>) for respondents by use of the Internet; were analysed in the second step of data analysis.

The evaluations of question q<sub>17</sub>, q<sub>16</sub> and q<sub>15</sub> are the following: Total 62 men (24.6%) and 65 women (25.8%) stated lack of time as barrier; 17 men (6.75%) and 15 women (5.95%) worry about security and privacy; 12 men (4.76%) and 13 women (5.16%) have problem with accessibility of computer with connection to the Internet; 30 men (11.9%) and 38 women (15.08%) have other reasons for barriers.

Total 24 seniors (9.52%) stated the incomprehensibility and disbelief to contents of the Internet; 118 seniors (46.83%) has problem with an advertisement in websites; 15 seniors (5.95%) stated the complicated manageability. Total 33 respondents (13.10%) state the low cost of the Internet as the positive. The most of respondents (123; 48.81%) prefer quick information retrieval and 64 respondents (25.40%) stated easy manageability as the most important positive of the Internet. The occurrence of advertisement in the web sites inconvenience respondents that prefer quick retrieval of information (61; 24.21%) or easy manageability (46; 18.25%) as the most important positive of the Internet.

Group 3: Social Networks, Digital Technologies etc. The questions focused on the purpose of the use of computer (q<sub>10</sub>); the use of services in the Internet (q<sub>13</sub>); the communication by the social networks (Panuš, Jonášová, 2014) (q<sub>14</sub>); the use of digital technologies (q<sub>28</sub>) fall into the third group of analysed questions.

Total 37 seniors use the Skype to the communication; 42 seniors are in the Facebook and 5 communicate by the Twitter; only 3 seniors use the ICQ or Miranda. Digital technologies as digital camera or smart phone are commonplace for approximately 44 % respondents (40 men and 25 women use digital camera; 26 men and 21 women use smart phone); and in total 35 men and 45 women do not use any digital technologies. Common services as e-banking, shopping and retrieval of information use approximately 88 % respondents that use computer (10 men and 15 women do only shopping and 8 men and 23 women use e-banking; 89 men and 78 women use the Internet to retrieval of information). Numbers of respondents from point of view age groups and use of e-banking, shopping and information retrieval we can see in Table 3.

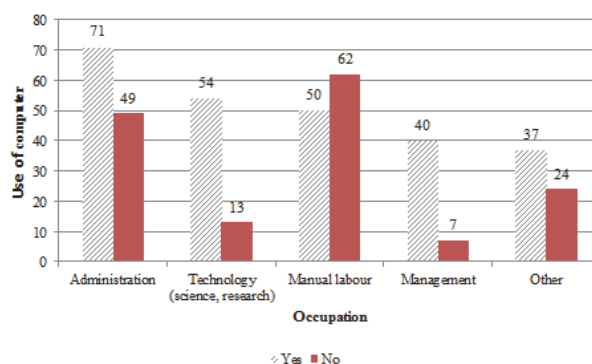


Figure 1: Use of computer by occupation

Table 3: Use of services in Internet by age groups

Age group	Use of services in Internet		
	E-banking	Shopping	Retrieval of information
less than 65 years	7 (2.78%)	8 (3.17%)	74 (29.37%)
from 65 to 70 years	10 (3.97%)	9 (3.57%)	51 (20.24%)
from 71 to 75 years	9 (3.57%)	7 (2.78%)	20 (7.94%)
from 76 to 80 years	5 (1.98%)	1 (0.39%)	20 (7.94%)
81 years and more	0 (0.00%)	0 (0.00%)	2 (0.79%)

Group 4: Computer Literacy of Respondents. The data analysis of this group of questions focused on abilities of respondents to work with text editors (e.g. MS Word; q<sub>18</sub>); spreadsheets (e. g. MS Excel; q<sub>19</sub>) and file managers (q<sub>21</sub>). It deals with area of hardware (q<sub>27</sub>) and evaluated ability to do presentations in e.g. MS PowerPoint (q<sub>20</sub>).

The data analysis indicated 11 owners of the ECDL certificate (9 men and 2 women). In total 1.59% (4) of women and 15.08% (38) men know how to work with hardware and majority of seniors (210; 83.33%) do not know it. Approximately 73% of respondents know to work with some file manager and 51% can do easy tables in some spreadsheet. Majority of respondents (75%) know and use some text editor. In total 67 (27%) seniors can create and 163 (65%) can not create easy presentation. Numbers of respondents from

point of view age groups and use of text editors, spreadsheets and file managers (selected values of answers) we can see in Table 4, Table 5 and Table 6.

Table 4: Use of text editors by age groups

Age group	Use of text editors		
	To writing of easy short text	To writing of an extensive text	I do not use it
less than 65 years	73 (28.97%)	10 (3.97%)	13 (5.16%)
from 65 to 70 years	56 (22.22%)	7 (2.78%)	13 (5.16%)
from 71 to 75 years	26 (10.32%)	2 (0.79%)	10 (3.97%)
from 76 to 80 years	13 (5.16%)	2 (0.79%)	16 (6.35%)
81 years and more	1 (0.39%)	0 (0.00%)	4 (1.59%)

Table 5: Use of spreadsheets by age groups

Age group	Use of spreadsheets		
	Creation of easy table	Creation of graphs	I do not use it
less than 65 years	63 (25.00%)	3 (1.19%)	29 (11.51%)
from 65 to 70 years	47 (18.65%)	3 (1.19%)	22 (8.73%)
from 71 to 75 years	11 (4.37%)	1 (0.39%)	27 (10.71%)
from 76 to 80 years	8 (3.17%)	0 (0.00%)	21 (8.33%)
81 years and more	0 (0.00%)	0 (0.00%)	5 (1.98%)

Table 6: Use of file managers by age groups

Age group	Use of file managers		
	I work alone	I work but with the help of another person	I do not know it
less than 65 years	84 (33.33%)	1 (0.39%)	7 (2.78%)
from 65 to 70 years	63 (25.00%)	2 (0.79%)	6 (2.38%)
from 71 to 75 years	24 (9.52%)	4 (1.59%)	9 (3.57%)
from 76 to 80 years	12 (4.76%)	5 (1.98%)	10 (3.97%)
81 years and more	0 (0.00%)	0 (0.00%)	3 (1.19%)

If we compare results of data analysis by education, 63 (25%) academically educated respondents and 71 (28%) secondary educated respondents use the text editors to writing of short texts. 16 (6%) of academically educated write extensive texts and 7 (3%) with this education do not use this type of software. In total 20 (8%) secondary educated respondents do not use this software, too.

## Creation of Classification Model

We suppose that it is possible to classify respondents by their preparation for an obtaining the ECDL Certificate (by their computer skills) and selected inputs (attributes) e.g. sociodemographic indicators, barriers in use of the internet and purpose of computer use.

The ECDL has several levels. The basic is Start level. Who is interested by Certificate ECDL Start, has to complete the tests successfully in areas (modules): work with file



manager and PC (q<sub>21</sub>), with text editor (q<sub>18</sub>), work with the Internet (q<sub>12</sub>) and at least one other optional module (q<sub>19</sub>, q<sub>20</sub>, q<sub>25</sub>). On the basis mentioned areas the output attribute (q<sub>29</sub>) with values dissatisfied (61; 24.21%), below average (29; 11.51%), average (91; 36.11%), above average (70; 27.78%), excellent (1; 0.40 %); value dissatisfied means "senior is not ready to be certified") was derived. The size of final data set for modelling was 252 objects (seniors) described by 23 attributes (attributes q<sub>12</sub>, q<sub>18</sub>, q<sub>21</sub>, q<sub>19</sub>, q<sub>20</sub>, q<sub>25</sub> that were used for derivation of the new output attribute were discarded from the final data set). Classification models were created in IBM SPSS Modeler.

Selected algorithms of decision trees C5.0, CRT, QUEST, CHAID were used for classification model creation (with inputs q<sub>2</sub>, q<sub>3</sub>, q<sub>4</sub>, q<sub>5</sub>, q<sub>6</sub>, q<sub>15</sub>, q<sub>16</sub>, q<sub>17</sub>, q<sub>24</sub>, q<sub>26</sub>, q<sub>28</sub> and output q<sub>29</sub>). Results of modelling by C5.0 and C5.0 with boosting are in Table 7. Results of classification based on CRT (AR<sub>Test</sub> is 44.95%), QUEST (AR<sub>Test</sub> is 36.70%) and CHAID (AR<sub>Test</sub> is 48.62%) algorithms were very low.

Table 7: Results of modelling

Algorithm	AR <sub>Train</sub> (in %)	AR <sub>Test</sub> (in %)	Difference (in %)
C5.0	80.42	78.90	1.52
C5.0 boosting	91.61	91.74	0.13

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## DISCUSSION AND CONCLUSION

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The objective of this paper was to analyse the level of the computer literacy of seniors in given interest area. Results of the socio-demographic analysis are the following: typical respondent that does not use computer is in age category "over 80 years", and he worked manually during his life. Conversely, respondent that uses computer has secondary or higher/academic education. He worked or he still works in science, technology and management. His age is below 65 years.

The data set of 252 computer active respondents was created from the total number 407 respondents. Total 66% of all 252 respondents use computer and the Internet daily. Majority of them worked with computer in occupation.

Total 38% respondents use computer for purpose of the communication. Approximately 66% respondents use the Internet as source of information. The most important positive for respondents is the quick information retrieval. Conversely, the most important negative is the occurrence of an Internet advertisement. The lack of time is the biggest barrier of the frequent use of the Internet. They most commonly use text editors where they do easy and short texts. Text editors do not use approximately 22% of respondents. Over 41% of respondents do not use spreadsheets. Respondents who use this type of editors have mainly focused on the creation of easy tables. Approximately two third of respondents do not use applications to creation of presentations. About 73% respondents work alone in a file manager and can create, rename or remove files or directories. Only very small part of respondents (11) with academic or secondary education is owner of the ECDL certificate. These owners of the ECDL certificate worked in area of science, technology or in management. Total 14% respondents have ever been on a computer course for seniors. The most of seniors prefer Internet as the best way of education in area of information technologies (33%), and 37% are not interested to educate themselves in this area.

From the viewpoint of computer security, practically 49% of respondents use basic program settings to protect your computer. Total 54% users are satisfied with their computer knowledge and computer skills. Who is interested in further education, he would like to improve their skills in area of basic computer control. Total 17% of respondent understand hardware.

Result of the analysis and their subsequent evaluation confirmed the assumption computer literacy declines with age. It is probably due the fact that people aged over 80 years in their active working life did not have the opportunity to acquire work on computers and other digital technologies. This trend is likely to continue given the ever evolving and expanding modern approaches to information technologies.

Similar conclusion we can do based on decision rules described classification models created by application of decision trees. They particularly show significance of education and age attribute. The computer skills and knowledge of respondents is better with higher education of respondents. However, age has negative influence in this area. Older seniors with higher education have worst computer skills in greater age.

Interesting facts were also found in the context of a personal data collection by questionnaire. Many senior citizens would like to acquire the skills associated with the use of information technologies with a view to better integrate into the team of the young generation (grandchildren or great-grandchildren of seniors represent those generations for them). The unavailability of computers with Internet connection is barrier in many cases. It is to consider whether access to computers connected to the Internet in places, where participate in their activities, would increase not only their level of computer literacy but also the overall quality of their everyday lives.

In this paper we dealt with data analysis and with classification model creation in area of computer literacy of seniors. We applied selected algorithms of decision trees, but only algorithm C5.0 gave reasonable results of classification. Why other algorithms showed very low values of classification we will solve in the future work. Data obtained from the survey will be further used for finding interesting relationships and connections in data based on selected cluster analysis methods and association rules etc. (Han, Kamber, 2006; Witten, Frank, 2005; Maimon, Rokach, 2005), too.

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# Simple Distance Line-point Algorithm for Line Extraction from 2D Laser Data

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## Abstract

*To get information about surrounding environment in robotics experts use laser distance sensor the most nowadays. 2D laser range finders usually provide the robot a large number of the accurate data compared to other sensors (ultrasonic, infrared). There are other useful qualities of these data as wide viewing angle, high frequency scanning or small angular resolution. These data describe the environment, where they were taken, quite well. In order to perform robotic tasks, whether essential (front obstacle stop), or complex, such as mapping and localization, or both of them simultaneously, it is necessary to process the input data appropriately. A method of processing the input data is dependent on the environment where they were acquired to some extent. Structured qualities of the data are used mainly for the data obtained indoors. Lines are searched for among other data the most often. The lines represent, for example, straight walls of a room or hallway. Other geometric shapes as circles or ellipses can be searched among the data. This paper presents a simple incremental algorithm DILIP. This algorithm is based on an analytical calculation that is suitable for embedded devices and systems with limited computing power. DILIP algorithm was tested on the data obtained through a low-cost laser rangefinder RPLidar. The data was taken in a normal office environment.*

## Keywords

*Line extraction. 2D laser. RPLidar. Range finders.*

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## INTRODUCTION

Mapping and localization are discussed topics in the field of mobile robotics. The algorithms solving these two problems simultaneously have been developed in recent years. The biggest advantage of this current solution is the possibility of obtaining and storing information about the environment where the robot moves while the acquired data perform localization (determining robot's own position in the environment) at the same time. These algorithms are called SLAM - in short (Simultaneous Localization And Mapping). SLAM algorithms can process the data obtained from various sensor types. Laser distance sensors are used the most often, because of their favourable qualities, such as the sampling rate, a large amount of the measured data in one period and finally the measurement accuracy. A lot of authors are interested in laser data application for

locating and mapping the unknown environment, for example the application of laser scanner data for the detection of doors indoors and the use of this information for locating robot (Fernández-Caraméz, et al., 2016). (Sileshi, et al. 2016) presents application of programmable gate arrays (FPGAs) with embedded the particle filter applied to SLAM algorithm that uses a low-cost sensor Neato XV-11. Not only the data obtained from the laser are used to increase the accuracy of detection of obstacles, and to localize combination of laser and image data can be used as well (Shalal, et al., 2015). (Shi, et al., 2015) use a combination of laser data and the data acquired from the panoramic camera to localize precisely in dense urban environments where GPS is useless. (Lenac, et al., 2016) present Active SLAM algorithm. The input data of this algorithm are acquired by Kinect sensor. These data are made more precise through the data odometry (encoders wheels and inertial measurement unit). Active SLAM algorithm is able to operate in real time.

A proper segmentation of the input data is the essence of localization and mapping algorithm. The problem of a proper segmentation of the input data is crucial for appropriate running of the whole algorithm, whether considering mapping, localization or SLAM. The data can be processed by various methods (Andrs, et al., 2013), (Beranek and Knizek, 2012), (Konecny, et al. 2010), (Magdin, et al. 2013), (Munk, et al. 2011), (Munk, et al. 2015) and (Ondrousek, 2009), depending on the surrounding environment. Probability approaches are used the most in a diverse outdoor. MCL (Monte Carlo Localization) algorithm is a very popular probability algorithm. (Thrun, et al., 2001) presents basic and enhanced MCL algorithm. Segmentation methods searching for straight lines are used the most indoors. Straight lines may, for example represent walls of the room. There is a plenty of algorithms for lines searching among the data, whether considering the image data or the data collected by laser scanning. Split-and-Merge algorithm is one of very popular algorithms that perform the extraction of lines from 2D laser data. This method was developed primarily for digital image processing in 1974 and is based on the representation of data using quad-tree structure. Quad-tree is a tree structure where each node has either just four off springs or none of them. An image and its sub images are successively divided into four quadrants, if the area under defined conditions is determined as inhomogeneous. However, when the condition of homogeneity is met, the adjacent quadrants are connected (Pavlidis and Horowitz, 1974). For example, (Borges and Aldon, 2004) and (Faruquzzaman, et al., 2008) are also papers dedicated to this algorithm. Hough Transform is another algorithm coming from computer image processing. This method is used to detect the objects whose edges can be described parametrically using lines. Modification then enables to detect other objects, such as a circle, ellipse, etc. This method is based on the transformation of polar coordinates into Cartesian coordinates and can be characterized by high resistance to noise. Publications (Xu, Shin and Klette, 2015), (Grigillo, et al., 2015) and (Ravankar, et al., 2014) deal with the use of the Hough Transform. RANSAC (Random Sample Consensus) algorithm is a very popular algorithm not only in computer image processing. RANSAC is an iterative method of calculating the parameters of a mathematic model from the investigated data. This method was first described in 1981 (Fischler and Bolles, 1981). The basic premise of this method is that the input data contain inliers (points that describes searched model) and outliers (points that do not describe searched model and make direct calculation of the model parameters impossible). Based on the random selection of the minimum number of points required to assemble a searched model from the input data we get the evaluation how the model built

on these points matches the searched model. The top rated model during iteration is the demanded one. RANSAC algorithm can be used for the motion estimation (Nister, 2003), for example. Incremental algorithm, also known as LT (Line Tracking), is a method used in many applications, for example in the mobile robot navigation (Taylor and Probert, 1996). The main advantage of this method of segmentation is its simplicity and the ease of implementation even in embedded devices. This method is based on predicted arrangement of measured points. It uses analytical calculations in order to determine whether the next measured point is or is not included in one line. At the beginning, it takes the first two measured points and the estimated distance of a following point is calculated from the known triangle. This calculation is compared to the actual measured value and when the difference of these two values is less than a predetermined error, the point belongs to the line. The calculation is repeated with the first and the last calculated point up to the time when the difference of the calculated and measured point is greater than the permissible error. At that moment, information about the straight line is stored and the calculation starts again from the point where the lines are interrupted. (Nguyen, et al., 2005) compares parameters of some of the above mentioned algorithms. Incremental algorithm has been evaluated as the second fastest with a very good success rate of good and bad positions of found lines from the experimental results (Nguyen, et al., 2005).

The development of simple and sufficiently effective algorithms for embedded devices is as important as the development of highly accurate and robust algorithms. Accuracy and robustness are largely compensated by relatively high demands on computing power, or as stated in (Thrun, et al., 2001) high demands on the data (read speed, data density). This paper goes on with presenting analytically a simple incremental algorithm with the working title DILIP (Distance Line-Point) that is suitable for embedded systems. A low-cost sensor RPlidare provided the test data. Rplidar's scanning angle is 360 ° and measuring distance 6 m, the sampling rate is 2000 samples per second and the speed of rotation of the scanning head is controllable by PWM modulation. The test data had 325 points per revolution, which corresponds to the rotational frequency of about 6 Hz.

## **METHODS**

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The structured data acquired by laser scanning of the internal environment are a prerequisite for the use of DILIP algorithm. DILIP algorithm works in two phases. The original data from the laser scanning are read in the first phase. The first segmentation is performed with these data. Already segmented data (lines, respectively coordinate of their start and end points) are considered in the second step will take and it is checked if it is possible to join some of other lines.

### **Principle DILIP**

A simple DILIP equation (1) to calculate the distance of the point from the line is the heart of the algorithm. This equation is used both in the first and in the second phase of the algorithm.

$$d(A, p) = \frac{x_A \cdot (y_1 - y_2) + x_1 \cdot (y_2 - y_A) + x_2 \cdot (y_A - y_1)}{\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}} \quad (1)$$

Where are  $P_1 = [x_1, y_1]$ ,  $P_2 = [x_2, y_2]$  points belonging line and  $A = [x_A, y_A]$  is point of distance calculate.

DILIP takes the first three measurement points in the first phase of segmentation, the first and second points are interleaved by line. DILIP calculates the perpendicular distance of the third point from the line. If this distance is smaller than the selected accuracy, the third point belongs to the line. The calculation is repeated with the first, the third, and the fourth point. If the distance of the fourth point from the line is greater than the accuracy, the information about segment line is stored in the form of a coordinate of the starting and end point of the segment line (the first point and point 3). The calculation continues with the fourth, the fifth and the sixth point. Figure 1 (left) shows the situation of both variants. The test algorithm implementation was performed in Octave and its graphic superstructure Qt octave. The flowchart was created to clarify how the algorithm was implemented. Figure 2 shows the flowchart of the first phase of algorithm DILIP.

Algorithm DILIP takes the starting point of the first stored segment line and the endpoint of the other stored segment line in the second phase. These points are interleaved by a line. Furthermore, the distance of the initial point of the second line from the fitted straight line is compared. If the distance meets a selected precision, the new segment line is stored with a starting point of the first line and the endpoint of the last satisfactory controlled line. The situation of the second phase of segmentation is again shown for both variants in Figure 1 (right).

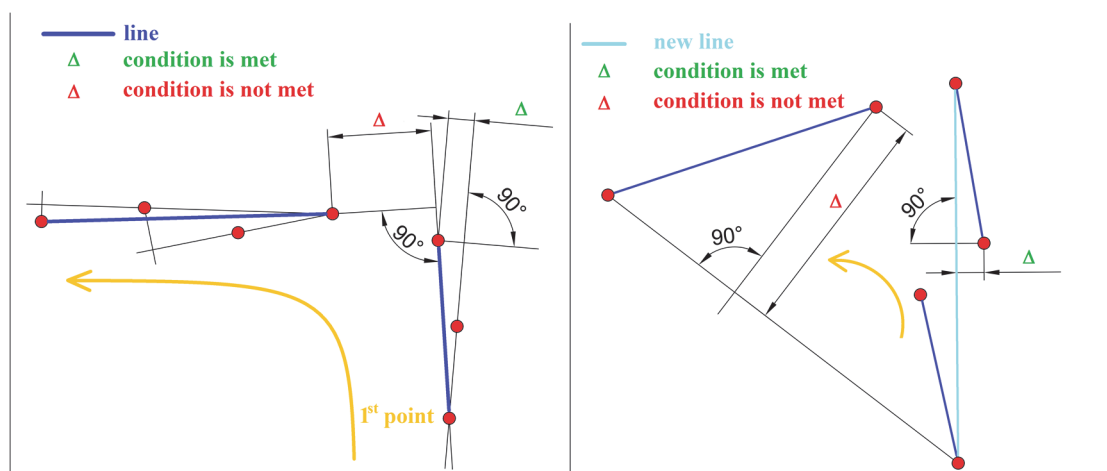


Figure 1: The first and the second phase of segmentation.

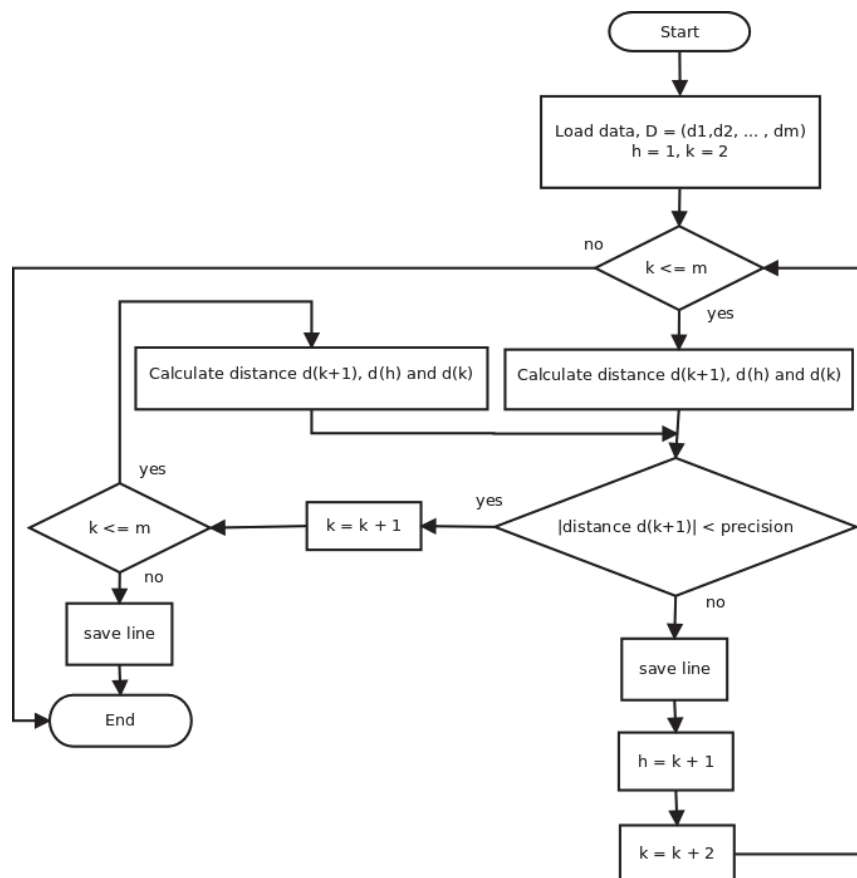


Figure 2: The flowchart the first segmentation phase.

## RESULTS

The accuracy of the comparison of the calculation one centimeter was chosen the analysis of the test data taken by RPlidar. This accuracy was chosen for both the first and the second phase of segmentation in its entirety data extent. This option has been experimentally verified on a set of test data. In principle of DILIP algorithm the option of the accuracy for comparing the calculating is a key parameter that significantly affects the quality of the entire result. The choice of accuracy also depends on certain characteristics of the input data (data density, distance measurement and related sensor accuracy). All relations for the choice of accuracy of the algorithm has not been examined in details yet, and can be one of the suggestions for future work on DILIP algorithm.

The presented results are deduced from an artificially created environment of approximate dimensions of  $1.3 \times 2.3$  m (environment A) and  $2.2 \times 3.6$  m (environment B). The materials of the obstacles in both environments correspond to real materials of a normal office environment. Figure 3 shows the results of the DILIP algorithm in the environment A. The results are shown for random three following consecutive processed scans. The left side of Figure 3 always shows in the original data collected by the sensor and the right side shows the segment line after the segmentation by DILIP algorithm. The values listed on the axes in the graph correspond to meters in effect. The yellow axis detect the sensor position, green circles present the initial and the final points of segmented lines and red color shows each line after the first and the second phase of



segmentation. Figure 4 shows results of the random sample (randomly selected three following consecutive processed scans) segmentation by DILIP algorithm of environment B.

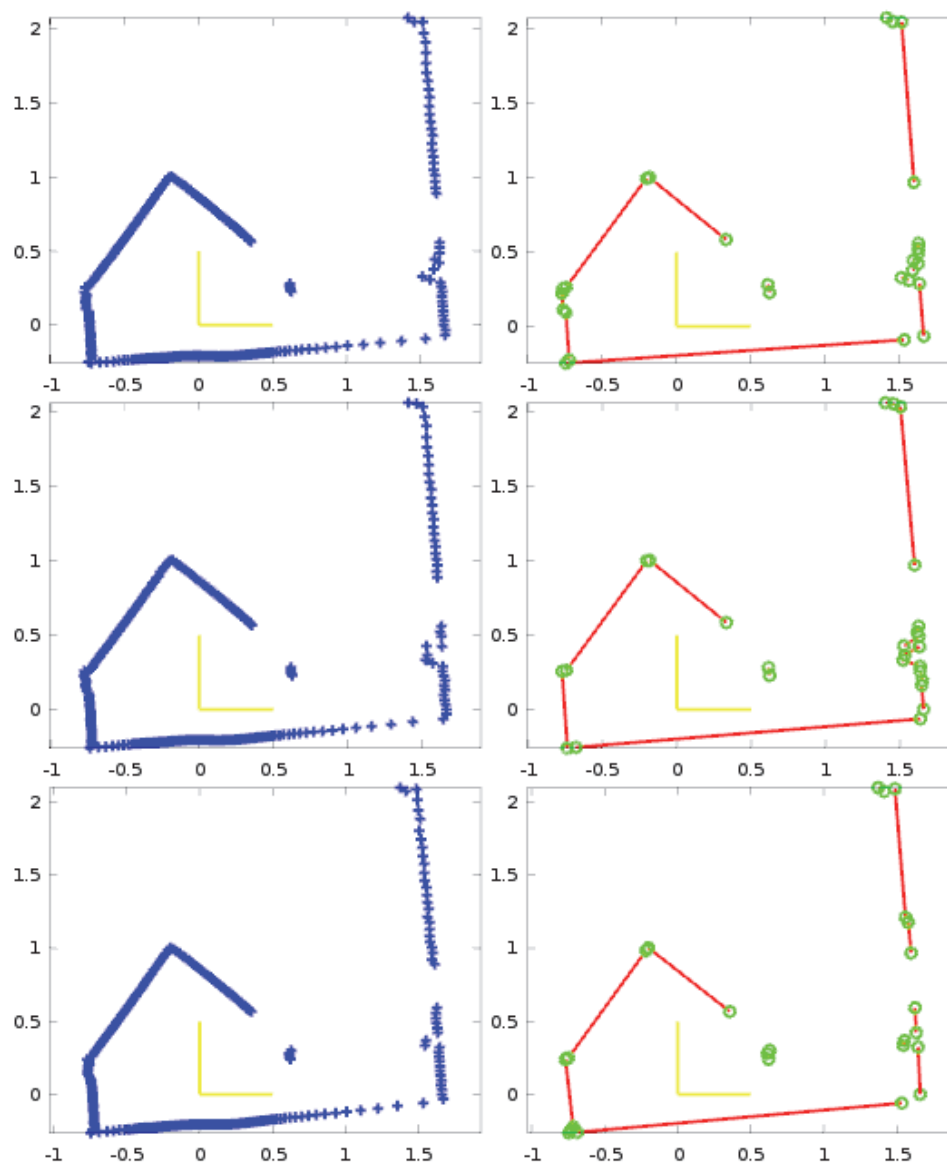


Figure 3: Environment A.

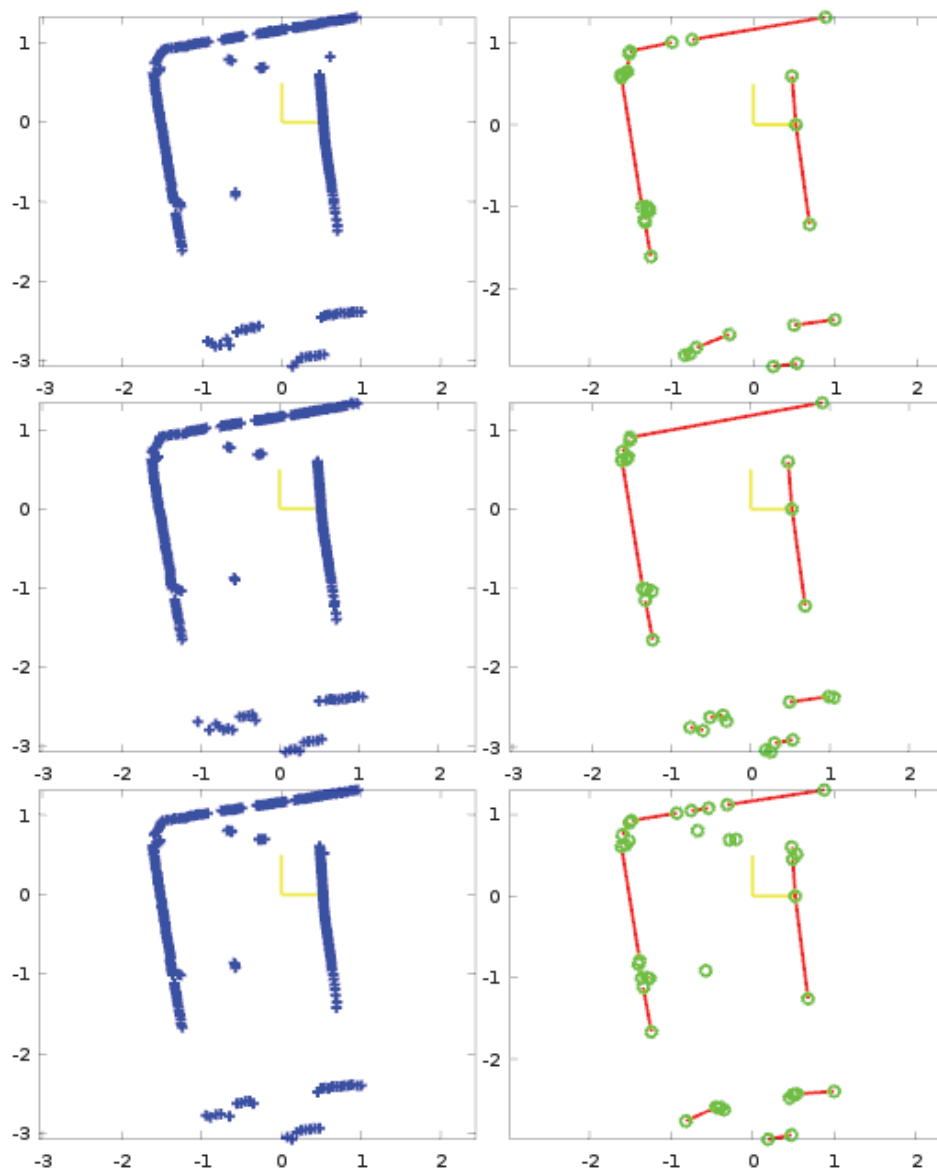


Figure 4: Environment B.

## DISCUSSION

The results of testing of the algorithm on the real data showed that despite its simplicity, it can fairly carry out the task it was designed for - the segmentation of lines of 2D laser data. DILIP algorithm is not perfect, as it can be seen in the results in Figure 3 and 4, but we must take into account that DILIP algorithm works with the coordinates of raw data all the time and does not use any approximation and optimization techniques or models of the environment that may increase demands of algorithm. The results are also presented with the use of the input data, but with a significantly reduced number of individual points (depending on the environment jaggedness). The output data are raw as well, exactly as it was processed through an algorithm, and no further filtration was made with them. High speed of the algorithm is determined mainly by its simplicity and relatively

sparse data processing of a low-cost sensor. A simple implementation, even in embedded devices, is one of the biggest advantages of DILIP algorithm besides its speed.

### Future works

As it was already mentioned above, a detailed analysis of the input data and dynamic assignment of options of the accuracy for comparing of the distance of a line item for each step of the algorithm is one of the options for future work on DILIP algorithm (Sánchez, et al., 2014). This could be the way to achieve greater robustness of the algorithm, but it increases the complexity at the same time. The question is whether the increasing complexity of the algorithm is worth trying, and if it can lead to significantly better results. Other planned work on the algorithm is associated with detection of important points in the scanned environment. These important points may be corners of rooms and they may not always be only internal corners, because outer corners (corners, cabinets and other) may be detected as well. Stress will be put again on as great simplicity as possible. Furthermore, there is the possibility of an algorithm application in robotic mapping, issue of appropriate filtering the output data of algorithm and scanmatching is related to this topic. The possibility of using DILIP algorithm for locating a mobile robot is also offered, and a problem solution of important points detection of the scanned environment is expected. By solving problems mentioned above, a simple SLAM algorithm would be created that should be suitable for the most of embedded devices with the input data acquired by the low-cost sensors.

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# Experimental Data Analysis: Verification of a Didactical Efficiency of a Course

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## Abstract

*The article deals with analysis of covariance, which we account as an optimal method by the data processing pretest-posttest. In the second part of the article we present and sample of the ANCOVA application for the purpose of experimental data processing. The aim of the paper is to describe an approach to optimal processing of experimental data pretest-posttest type using method ANCOVA and show how this method can be used to verify the didactical efficiency of a course. We have utilized two methods to solve experimental study, the analysis of variance and the analysis of covariance, whereby the analysis of variance simpler is and does not require assuming a consistency of posttest regression on pretest in individual groups. On the other hand, the interpretation is less valid if differences in pretests occur between the groups. Similar as in other situations it is recommended to utilize both types of analysis and compare their results.*

## Keywords

*Experimental Data Analysis. Pretest. Posttest. Assumptions Of Validity. E-learning. MOOC. Courses.*

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## INTRODUCTION

Research plans represent approaches allowing us to answer our research questions. Statistical survey and experiment belong to the basic research plans. Statistical investigation serves to observe the subjects and to record variables without manipulating these variables, whereas the variable is being manipulated in an experiment to determine the impact on the dependent variable. The objective of the research described in this article is the analysis of experimental data of the pretest- posttest type and comparison of the possibilities and results of two subjects of analysis – analysis of variance and analysis of covariance (Munk, 2011). The aim is to describe an approach to optimal processing of experimental data pretest-posttest type and through case studies show how this method can be used to verify the didactical efficiency of a course. One of the key elements of educational courses is to provide content to the students. Elearning courses take a prominent place in all levels of education and form an integral part of the educational process. Efficiency of elearning education and e-learning courses covers authors in his work (Poulová and Klimová, 2015; Hubalovský et al., 2015; Turčáni et al., 2012). Authors (

Grubišić et al., 2009) who deal of effectiveness evaluation and educational influence in courses in his work use various experimental plans, for a data processing they used method t-test for independent. Authors (Dietmar et al. 2004) presents the results of a twice replicated experiment that evaluates the learning effectiveness of using a process simulation model in course and they for data processing used methods like one-way paired t-test, one-sided t-test for independent samples, Wilcoxon matched pair test and Mann–Whitney U test. At present, the widespread are MOOC courses (Massive Open Online Course, MOOC), offering an open, informal and community education. MOOC is an online course aimed at unlimited participation and open access. MOOC courses have become nowadays, very popular, providing non-standard educational methods using the properties of distance informal education and provide interaction among groups of students and support community MOOC courses are also currently the most popular educational opportunity on the Internet, often from the best universities like (Harvard, Stanford, MIT) (edX, 2015; Baker, 2015). Jacobs believes that MOOCs represent the ultimate democratization of education, by making education more accessible to as many people as possible (Jacobs, 2013). MOOCs require individual students to be able to self-regulate their learning (Littlejohn et al., 2016).

## METHODS ---

### One-way analysis of variance (one-way ANOVA)

One-way analysis of variance (single factor) (Tab.1) is the simplest form of analysis of variance investigating dependence between the quantitative and the qualitative variable (factor). The objective of analysis of variance is to determine whether differences between the mean values for the particular groups (according to the factor level) are statistically significant (variable depending on the factor) or if they are random (variable not depending on the factor). A significant F value of the statistic leads to the rejection of the null hypothesis on the equality the means and thus to the acceptance of an alternative hypothesis claiming that the mean of at least one group is differing from the others.

Model of the one-way analysis of variance:

$$Y_{ij} = \mu + \alpha_i + e_{ij},$$

where  $\mu$  is the mean,  $\alpha_i$  is the contribution (effect) of the  $i$ th level of the factor A and  $e_{ij}$  is the residual. The parameters  $\mu, \alpha_i, i = 1, 2, \dots, I$  are unknown and  $e_{ij}, i = 1, 2, \dots, I, j = 1, 2, \dots, n_i$  are independent items with the distribution  $N(0, \sigma^2)$ .

We are interested in one null hypothesis:

$$H_{0A}: \alpha_1 = \dots = \alpha_I = 0 \text{ (all effects are equal null)}$$

Equivalent model of a one-way analysis of variance:

$$Y_{ij} = \mu_i + e_{ij},$$

where  $\mu_i$  is the mean on  $i$ th level of factor A.

We are interested in one null hypothesis:

$$H_{0A}: \mu_1 = \dots = \mu_I \text{ (the means of the groups are equal)}$$

Both models and hypotheses are absolutely equal and lead to equal formulas.

Table 1: One-way analysis of variance (one-way ANOVA)

Variability	Degrees of Freedom	SS	MS	F
independent variable (A)	$I - 1$	$S_A$	$S_A/(I - 1)$	$MS_A/MS_e$
error (e)	$n - I$	$S_e$	$S_e/(n - I)$	
total (T)	$n - 1$	$S_T$	$S_T/(n - 1)$	

$I$  – number of levels attained by the independent variable.

$n$  – number of observations.

$SS$  – sum of squared deviations.

$$S_T(y) = \sum_i \sum_j (y_{ij} - \bar{y})^2 = \sum_i \sum_j (y_{ij} - \bar{y}_i)^2 + \sum_i n_i (\bar{y}_i - \bar{y})^2 = S_e(y) + S_A(y)$$

$MS$  – mean squares ( $SS/\text{degrees of freedom}$ ).

$F$  – test statistic ( $MS_A/MS_e$ ). If  $F_A \geq F_{I-1, n-I}(\alpha)$ , hypothesis  $H_0$  is rejected. Generally the  $F$  statistic has the following form in the analysis of variance:

$F = \text{weighted variance between groups' means} / \text{variance between subjects in the same group}$

$p$  – value of significance (conversion of  $F$  into a probability scale), if  $p$  is less than the chosen significance level  $\alpha$ , we reject the null hypothesis and accept the alternative hypothesis. Otherwise we do not reject the null hypothesis.

## Analysis of covariance (ANCOVA)

The analysis of covariance (Tab.2) blends elements of analysis of variance and multiple regression. One or more quantitative factors – covariates/covariance variables – are added to the model of analysis of variance examining the dependence of the intensive / quantitative variable on nominal factors.

Regression model for analyses of covariance in case of two groups and one covariance variable  $X$ :

$$Y_i = \beta_0 + \beta_1 x_i + \beta_2 z_i + \beta_3 x_i z_i,$$

where  $Z$  denotes the value of the indicator - artificial variable. It attains the value 0 or 1 depending on whether the measurement belongs to group one or two. The coefficient  $\beta_2$  reflects the effect of the nominal factor. The coefficient  $\beta_1$  evaluates the impact of the covariance variable. The coefficient  $\beta_3$  represents the presence of interaction between the covariate and the nominal factor.

Equivalent model of analyses of covariance with one nominal factor and one covariate:



$$Y_{ij} = \mu + \alpha_i + \beta(x_{ij} - \bar{x}) + e_{ij},$$

where  $\mu$  is the mean,  $\alpha_i$  is the contribution of the  $i$ th level of factor  $A$  and  $e_{ij}$  is the residual. The parameters  $\mu, \alpha_i, i = 1, 2, \dots, I$  are unknown and  $e_{ij}, i = 1, 2, \dots, I, j = 1, 2, \dots, n_i$  are independent quantities with the distribution  $N(0, \sigma^2)$ .

If the relation between  $X$  and  $Y$  is a significant one, then the model of analysis of covariance explains the higher variability of the variable  $Y$  rather than the model of analysis of variance. The analysis of covariance examines whether the altered means of the groups differ. The means are have been adjusted, as if the value of the intensive / quantity factor was equal (mean) in all groups.

Table 2: Analysis of covariance with one nominal factor and one covariate (one-way ANCOVA).

Variability	Degrees of Freedom	adjusted SS	adjusted MS	F
Independ-ent variable (A)	$I - 1$	$S_A(adj) = S_T(adj) - S_e(adj)$	$S_A(adj)/(I - 1)$	$MS_A(adj)/MS_e(adj)$
error (e)	$n - I - 1$	$S_e(adj) = S_e(y) - (S_e(xy)^2/S_e(x))$	$S_e(adj)/(n - I - 1)$	
total (T)	$n - 2$	$S_T(adj) = S_T(y) - (S_T(xy)^2/S_T(x))$		

$I$  – number of levels attained by the independent nominal variable.

$n$  – number of observations.

*Adjusted SS* – adjusted sum squares of deviations.

$$S_T(x) = \sum_i \sum_j (x_{ij} - \bar{x})^2 = \sum_i \sum_j (x_{ij} - \bar{x}_i)^2 + \sum_i n_i (\bar{x}_i - \bar{x})^2 = S_e(x) + S_A(x)$$

$$S_T(y) = \sum_i \sum_j (y_{ij} - \bar{y})^2 = \sum_i \sum_j (y_{ij} - \bar{y}_i)^2 + \sum_i n_i (\bar{y}_i - \bar{y})^2 = S_e(y) + S_A(y)$$

$$S_T(xy) = \sum_i \sum_j (x_{ij} - \bar{x})(y_{ij} - \bar{y}) = \sum_i \sum_j (x_{ij} - \bar{x}_i)(y_{ij} - \bar{y}_i) + \sum_i n_i (\bar{x}_i - \bar{x})(\bar{y}_i - \bar{y})$$

$$= S_e(xy) + S_A(xy)$$

*Adjusted MS* – adjusted mean square (adjusted SS / degrees of freedom).

$F$  – test statistic (adjusted  $MS_A$  / adjusted  $MS_e$ ). If  $F_A \geq F_{I-1, n-I-1}(\alpha)$ , hypothesis  $H_0$  is rejected.

$p$  – value of significance (conversion  $F$  into probability scale); if  $p$  is less than the chosen level of significance  $\alpha$ , we reject the null hypothesis and accept an alternative hypothesis. Otherwise the null hypothesis is not rejected.

## CASE STUDY

The teacher wants to find out, whether the created course has a positive impact on the results of the students. He chooses to examine its effectiveness in the field. To this

end, he conducts a research. He decides for an experiment as research method and for a didactic test (pretest, posttest) as research instrument. Research hypothesis is that the respective course is effective from a didactic perspective.

Research steps:

1. Creation of control group and experimental group.
2. Creation of valuable measurement procedure.
3. Realization of the experiment plan.
4. Data comprehension.
5. Verification of the validity of the statistical methods applied.
6. Data analysis and result interpretation.

Table 3: Input data table

	PRETEST	POSTTEST	GROUP
1	10	16.6667	CON
2	10	23.3333	CON
⋮	⋮	⋮	⋮
30	20	27.5	EXP
31	25	14.1667	EXP

*Solution.* The research concludes with pretest and posttest results for the experimental as well as the control group. The number of points (Tab.3) was for pretest and posttest has been recorded for each student individually. The maximum number of points a student could get for the pretest (posttest) is 40 (35).

Table 4: Descriptive characteristics

	Level of Factor	N	Post. Mean	Post. Std.Dev.	Post. Std.err	Post. -95%	Post. 95%	Pre. Mean	Pre. Std.Dev.	Pre. Std.err	Pre. -95%	Pre. 95%
Total		51	22.75	6.73	0.94	20.85	24.64	21.11	4.50	0.63	19.85	22.38
Group	EXP	28	26.43	5.91	1.12	24.14	28.72	20.60	4.41	0.83	18.89	22.31
Group	CON	23	18.26	4.67	0.97	16.24	20.28	21.74	4.62	0.96	19.74	23.74

The table (Tab.4) contains descriptive statistics (mean, standard deviation, standard error and 95% mean confidence interval), posttest and pretest score for both groups as well as for each group separately.

On the basis of these results we need verify the validity of the following hypothesis:

- 1.H0: There is no statistically significant difference in the findings regarding the respective field between the control group and the experimental group.
- 2.H0: The results of the posttest do not depend on using the course.

We would like to accept the first hypothesis on the basis of the results of the pretest, which would confirm our assumption of the equality of the knowledge level in the respective field with students from the experimental and the control group.

On the other hand, we want to reject the second hypothesis because by rejecting it the alternative hypothesis becomes valid, which claims that the results of the posttest depend on utilizing the course. In the light of the better mean of the posttest points achieved with the experimental group, this would be a confirmation of the hypothesis of our research:

The course is didactically effective.

To test the above-mentioned hypotheses we chose the analysis of variance (which equals in the case of two groups the t-test) and analysis of covariance. Prior to using these methods we have to verify the assumptions of their use.

### Verification of validity of the statistical methods used

#### Assumptions for the analysis of variance:

- Normal distribution of the dependent variable in the particular groups.

We verify the normality for dependent variables (posttest, pretest) in the particular groups according to the level of the factor (experimental, control group). We verify this assumption by checking the categorized normal graph of probability. In the graphs we compare the value distribution of the dependent variables in groups according to factor level with the normal distribution of probability.

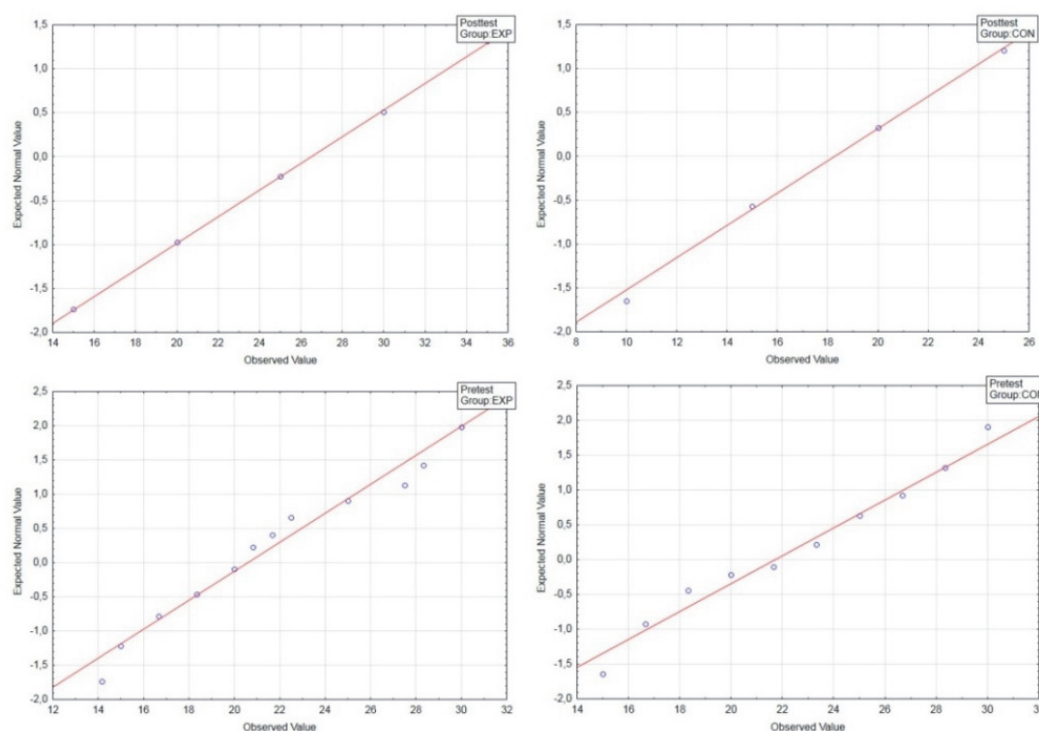


Figure 1: Normal probability graphs: (a) posttest EXP; (b) posttest CON; (c) pretest EXP; (d) pretest CON

It is apparent from the graphs, that the values of the dependent variables in the particular groups (Fig.1) copy normal distribution. It can be stated that the assumption is met.

- Equality of variances.

These tests (Tab.5) examine the following null hypothesis:

$$H_0: \sigma_1^2 = \dots = \sigma_i^2$$

Against the alternative H1 that H0 does not valid.

Table 5: Tests of variance homogeneity

	Hartley's F-max	Cochran's C	Bartlett's chi-square	p
posttest	1.599	0.615	1.277	0.2585
pretest	1.098	0.523	0.052	0.8203

Table 6: Levene's test for homogeneity of variances

	MS Effect	MS Error	F	p
posttest	9.302	8.155	1.141	0.2907
pretest	4.017	6.167	0.651	0.4235

The tests (Tab.6) are statistically insignificant ( $p > 0,05$ ), i. e. the hypothesis of equality of the variances is not rejected. We may state that no violation of the assumption occurred.

#### Assumptions for using analysis of covariance:

- Assumptions for the analysis of variance apply.
- Regression coefficient  $\beta$  is equal in all groups.

The simplest way to verify this precondition is to check the categorized correlation graph for each level of the factor. The quantitative factor is placed on the horizontal axis, the dependent variable on the vertical axis. The assumption is met if the individual lines show a roughly equal angle.

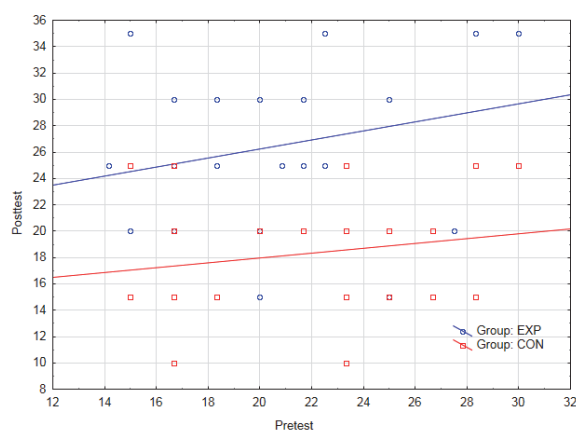


Figure 2: Correlation graph

The lines (Fig.2) are similar, i. e. the regression coefficient is roughly the same in both groups.

- Homogeneity of variance-covariance of matrices.

A multivariate test (Tab.7) is being used for testing the equality of variances. It serves the analyses of covariance and multivariate analyses of variance.

Table 7: Homogeneity test: Box's M test

	Box's M	chi-square	df	p
Box's M	1.404	1.341	3	0.7193

Since the test is statistically insignificant, the hypothesis of homogeneity of variance-covariance matrices is not rejected. We may state that no violation of the assumption occurred.

### Data analysis

Following methods have been chosen to analyze pretest-posttest type data:

1. Simple case analysis of variance applied separately to pretest and posttest data.
2. Analysis of covariance which is considered the optimal approach (applied to the results of the posttest as a dependent variable, whereby the pretest represents the covariate).

Table 8: Analysis of variance (posttest)

Effect	Degr. of Freedom	Posttest SS	Posttest MS	Posttest F	Posttest p
Intercept	1	25218.86	25218.86	868.216	0.0000
Group	1	842.39	842.39	29.001	0.0000
Error	49	1423.29	29.05		
Total	50	2265.69			

Table 9: Analysis of variance (pretest)

Effect	Degr. of Freedom	Pretest SS	Pretest MS	Pretest F	Pretest p
Intercept	1	22630.90	22630.90	1115.472	0.0000
Group	1	16.52	16.52	0.814	0.3712
Error	49	994.12	20.29		
Total	50	1010.64			

We reject the null hypothesis, which claims that the posttest score difference between experimental and control group is statistically not significant, i. e. the dependent variable *posttest* depends on the factor *group* (Tab. 8). On the other hand, we do not reject the null hypothesis which claims that the difference in the pretest score between experimental and control group is not statistically significant, i. e. the dependent variable *pretest* does not depend on the factor *group* (Tab. 9).

Table 10: Analysis of covariance

	Degrees of Freedom	Post. SS	Post. MS	Post. F	Post. p
Intercept	1	590.52	590.52	20.968	0.0000
Pretest	1	71.49	71.49	2.538	0.1177
Group	1	892.03	892.03	31.674	0.0000
Error	48	1351.80	28.16		
Total	50	2265.69			

According to the table, the relation between posttest and pretest is statistically insignificant ( $p = 0.112761 > 0.05$ ), i. e. results from pretest did not affect the results from posttest. We reject the null hypothesis which claims that the posttest score difference between experimental and control group (Tab.10) is not statistically significant, i. e. the dependent variable *posttest* depends on the factor *group*.

#### 4. CONCLUSION

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The didactic effectiveness has been verified using the abovementioned analysis; thus we have proven that the course had a positive impact on the results of the control test. We have verified the validity of the statistical tests to prove their strength. We have utilized two methods to solve this research problem, the analysis of variance and the analysis of covariance, whereby the analysis of variance simpler is and does not require assuming a consistency of posttest regression on pretest in individual groups. On the other hand, the interpretation is less valid if differences in pretests occur between the groups (Klocoková, 2011; Hvorecký, Drlík and Munk, 2010). Similar as in other situations it is recommended to utilize both types of analysis and compare their results. In our case the results are the same and we can consider them robust.

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# System for Post-Editing and Automatic Error Classification of Machine Translation

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## Abstract

*We describe a system for the manual and automatic classification of errors in machine translation output. The system was designed based on Vilar's et al. (2006) error classification and TAUS error typology (2013) taking into consideration the target language- Slovak. Slovak is an inflectional language with a "rich morphology" and can be categorized as a synthetic language with a loose word order. The system features manual evaluation in the form of post-editing and in the detection and classification of basic errors (Language, Accuracy, Terminology or Style) made by post-editors. Beside the manual classification of errors, based on POS tagging or morphological tag annotation, it also features automatic error detection and classification into morphological errors (incorrect word form), reordering errors (word order), missing words, lexical errors (incorrect words), unknown words and punctuation. The aim of this paper is to propose a framework and design a system for the purpose of determining which error types cause a problem for a given machine translation system, when translating a text of various styles (administrative, scientific and publicistic) into an inflectional language such as Slovak.*

## Keywords

*Natural Language Processing. Statistical Machine Translation. Sentence alignment. Tokenization. Word tagging. Morphological annotation.*

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## INTRODUCTION

The variability of research in the field of machine translation (MT) allows verification and application of various hypotheses in the fields of linguistics, information technologies and artificial intelligence; thus, MT is scientifically justifiable because it enables the discovery of mechanisms and theories of language computer modelling and language simulation functions.

MT systems are competitive systems with regard to the relationships of the three following parameters: quality-costs-speed; although MT systems are not time-consuming and are of low costs, they are of low quality compared to human translators. Hence, the



issue of MT systems quality emerges; the need to evaluate both MT generated texts, as well as MT systems. Therefore, the issue of evaluation is a key concept of MT. Inevitably MT evaluation is one element of research in the field of existing MT systems efficiency and their optimization. Progress in the field of MT depends on evaluation results and quality evaluation of new MT systems in order to prove their superior efficiency. Highly essential are the issues of methods and criteria designed for quality evaluation. From higher quality evaluation procedures, some are applicable in micro or macro-evaluation of translation - even nowadays.

As Williams (2001) suggests, there are two main procedures in translation quality evaluation: quantitative micro-text procedure and qualitative macro-text procedure. The basis of micro-text procedure is the evaluation of individual words or sentences in certain cases. This process includes several characteristics of quantitative procedures.

The paper is focused on introducing the goal of the current project- quantitative micro-text procedure drawing from the evaluation of translation errors (using linguistic knowledge).

The rest of the paper is structured as follows: the next section summarizes the main error classifications for machine translation in recent years. The third describes a framework for automatic error analysis (error identification and classification of MT output). The following two sections describe systems for the human evaluation of machine translation output and automatic error classification. The last section provides a conclusion and future direction.

## **RELATED WORK**

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Error classification of MT output depends on the MT system, the content and language pair; the classification shifts based on these factors.

There are several machine translation error classifications, whereby, the following objectives of both are identical: 1/ improving machine translation by giving specific feedback to the software engineers, 2/ increase awareness among the post-editors, point to the most common errors, in order to improve their works (activities).

Vilar et al. (2006) introduced their framework for human error analysis and error classification. Based on (Llitió et al., 2005), they classified five categories of errors: missing words, word order, incorrect words (inappropriate equivalent), unknown words and punctuation. Whereas missing words are content words (lexical errors), filler words (missing functional semantic categories), word order are word level (a local shift within the phrases), or phrase level (relocation of the phrase within one sentence). This classification has become widely used in recent years (Avramidis and Koehn, 2008; Max et al., 2008; Popović et al. 2011; Farrús et al., 2009). Automatic methods for evaluation are still needed, since human evaluation (where error analysis belongs) is subjective and time consuming.

Lopez and Resnik (2005) proposed a method for the automatic identification of patterns in translation output based on POS tagging. Popović et al. (2006) used relative differences between WER and PER for the estimation of inflectional and reordering errors or for discovering inflectional errors and missing word (Popović and Ney, 2007). Popović

(2011) describe a tool, Hjerson, which detects five error classes (majority defined in Vilar et al., 2006): morphological errors, reordering errors, missing words, extra words and lexical errors. The algorithm implemented in the tool combines word error rate (WER) with position-independent error rate (PER based on precision/recall).

## ERROR CLASSIFICATION

The goal of the proposed framework is to determine which error types cause a problem for a given machine translation system when translating a text of various styles (administrative, scientific and publicistic) into an inflectional language such as Slovak.

The aim of our framework for automatic error analysis consists of four objectives:

- To identify and classify errors in MT output.
- To identify the association rules for identified and classified errors.
- To identify the sequence rules for identified and classified errors.
- To identify the extent of mutual correlation between machine translation errors.

The pre-processing phase for automatic error classification proposed in our work is error identification based on similarities between MT output (hypothesis) and post-edited MT output (PEMT output) or reference, and POS tagging. When the errors have been identified, based on error typology guidelines by TAUS and the classification scheme used in (Vilar et al., 2006), we defined the following categories (Fig. 1).

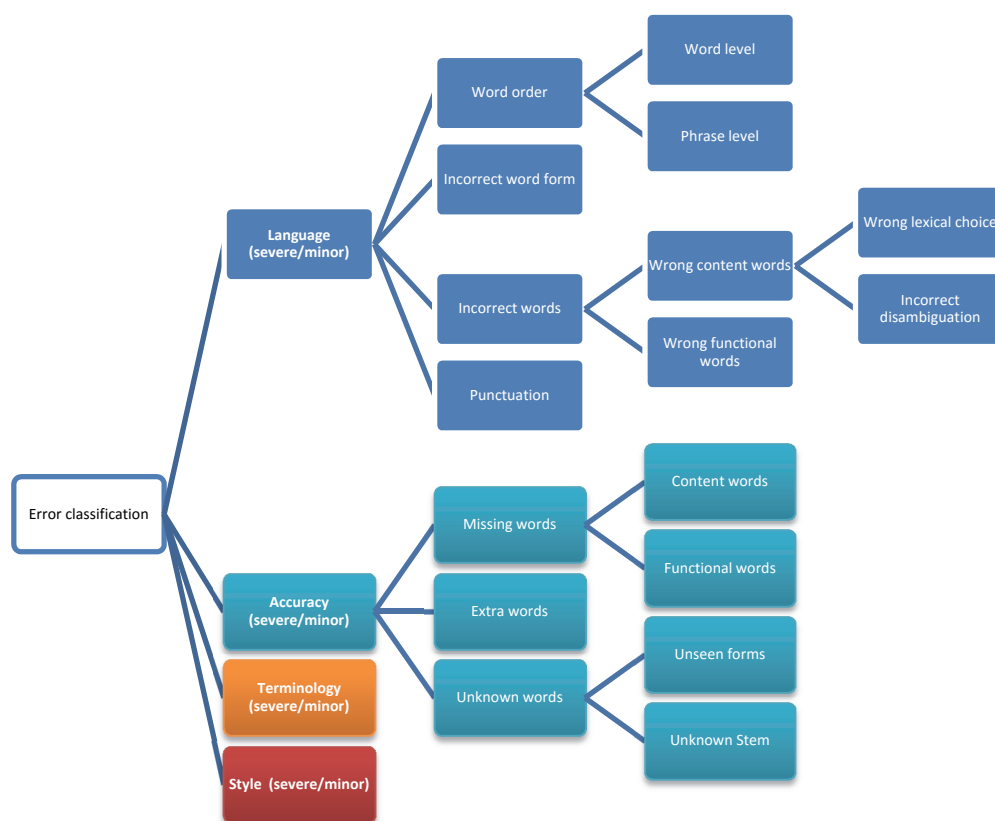


Fig. 1 Proposed error classification.

Category - Language generally means a grammatical, syntactic or punctuation error. It is the most frequent one, wherein four following subcategories are defined: a. *Word order*- at word level (a local shift within the phrases) or phrase level (relocation of the phrase within one sentence); b. *Incorrect word form*- incorrect word selection is caused by inability of the MT system to generate proper word form, even though the root word is correct; it is a specific characteristic of inflectional languages; c. *Incorrect words-sense/semantic shift* in sentence function caused by wrong translation or inability to identify correct meaning of a root word in the given context caused by word ambiguity; and d. *Punctuation*. The second category "accuracy" means unacceptable omission or addition, or not translated source word in the MT text. The category "terminology" represents an error in the glossary.

## SYSTEM FOR POST-EDITING AND MANUAL ERROR CLASSIFICATION

A system for manual evaluation of machine translation output was created. In our case, manual evaluation comprises post-editing and human error classification. The system offers a simple interface for effective postdating and error determination, i.e. it enables correction and determination of errors in MT output for the registered user (the user has an option to mark the error, which he/she had to correct).

Beside error correction, the users- post-editors offer a basic error categorization, i.e. they determine whether the mistake is from Language, Accuracy, Terminology or Style categories. The system enables the determination of several errors' classifications for the given sentence.

The screenshot shows a web browser window with the URL `localhost/machine_translation/view.php`. The page title is "Manual evaluation/post-editing and error classification". It displays a table with the following content:

#	Source text
221	One of the big advantages of li-fi is the fact that, unlike wi-fi, it does not interfere with other radio signals, so could be utilised on aircraft and in other places where interference is an issue.
<b>Machine translation (MT)</b>	
Jednou z veľkých výhod li-fi je skutočnosť, že na rozdiel od Wi-Fi, to nie je v rozpore s inými rádiovými signálmi, takže by mohli byť využité na lietadlách a na ďalších miestach, kde zásah je problém.	
<b>Post-edited MT</b>	
Jednou z veľkých výhod li-fi je skutočnosť, že na rozdiel od Wto nie je v rozpore s inými rádiovými signálmi, takže by mohli byť využité na lietadlách a na ďalších miestach, kde zásah je problém.i-Fi,	
<b>Basis error classification</b>	
<input type="checkbox"/> Language <input type="checkbox"/> Accuracy <input type="checkbox"/> Terminology <input type="checkbox"/> Style	

At the bottom of the table, there are two buttons: "Previous Sentence" (orange) and "Save and Next Sentence" (green).

Figure 2: Example of the application interface.

For a better description of the relationships between the system and its user, i.e. for a description of system behavior from the user perspective, we defined the following functional requirements for the application:

- to upload and process a file with the source text,

- The PHP language and MariaDB database were used to create the system. In terms of usage complements of the third sites, the CSS Framework Twitter Bootstrap, PHP library PHPEXcel and JavaScript framework JQuery together with Tabledit library were also used. The visual appearance of the interface for post-editors in the system is depicted in (Fig. 2).

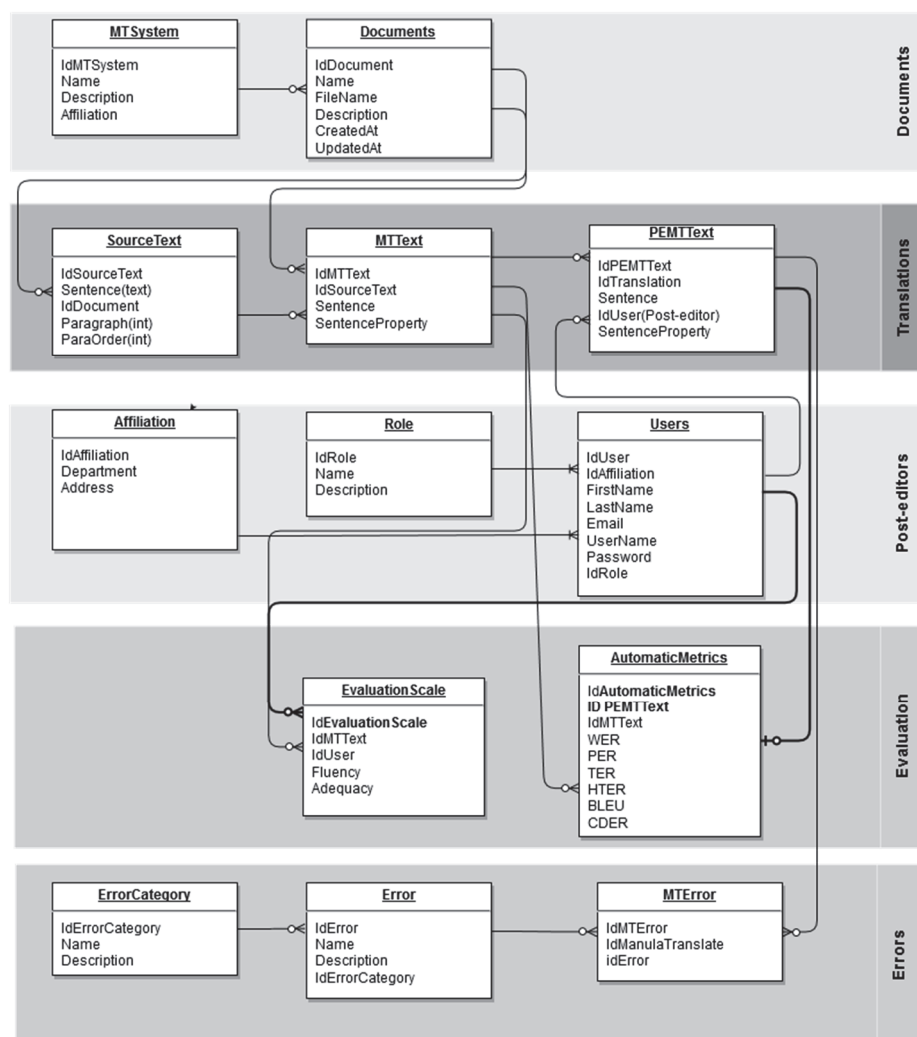


Figure 3: Application of the ERD scheme.

By the system design for post-editing and manual error classification of machine translation output, various diagrams were created, which help to explain its implementation. The ERD scheme of the application with database design were the basis of the system (Fig. 3).

The part „Translations“ is an important group of tables. It comprises tables for storing source sentences as well as individual sentences of MT output and sentences of PEMT output from various users (post-editors). Together with the group of “Errors” tables, they will also be used in the system for post-editing and manual error classification. The “MT error” table belongs to the group of “Errors”, it is a connected table for Errors editing within the individual sentences of MT output.

## **SYSTEM FOR AUTOMATIC ERROR CLASSIFICATION**

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The created system for evaluation is based on the idea of automatic errors detection. The aim is to simplify the work for post-editors, to minimize their subjectivity and the error rate during error detection or to forget to change tracking. The changes made by post-editors represent the found and determined errors of MT systems. The detection of automatic errors comes from the assumption, that the morphological tag annotation will be applied to sentences of machine translation output and also to post-edited sentences of machine translation output. Subsequently, the automatic system for error detection compares tags of individual words of MT sentence with corresponding words in a given PEMT sentence. Based on this comparison, the errors of machine translation output will be identified. An example of the procedure of error identification is depicted in the picture (Fig. 4).

The comparison of morphological tag annotation of machine translation output (MT text) with morphological tag annotation of post-edited machine translation output (PEMT text) will be the fundamental process for evaluation of machine translation. For this reason, the rules will be define, which will be used during the automatic errors detection. The rules will be created by the linguists of target language. The linguists will define the rules based on differences between tags of two corresponding words (tag annotation of MT word vs. tag annotation of PEMT word). The system will be registered the rules in standard rules' format: IF (word tag annotation in MT output) will be change to (word tag annotation in PEMT output) THEN (ERROR XYZ is occurred). This rules' structure will enable to make easier rules editing, primarily it will improve the time consuming nature of algorithm for MT evaluation of errors.

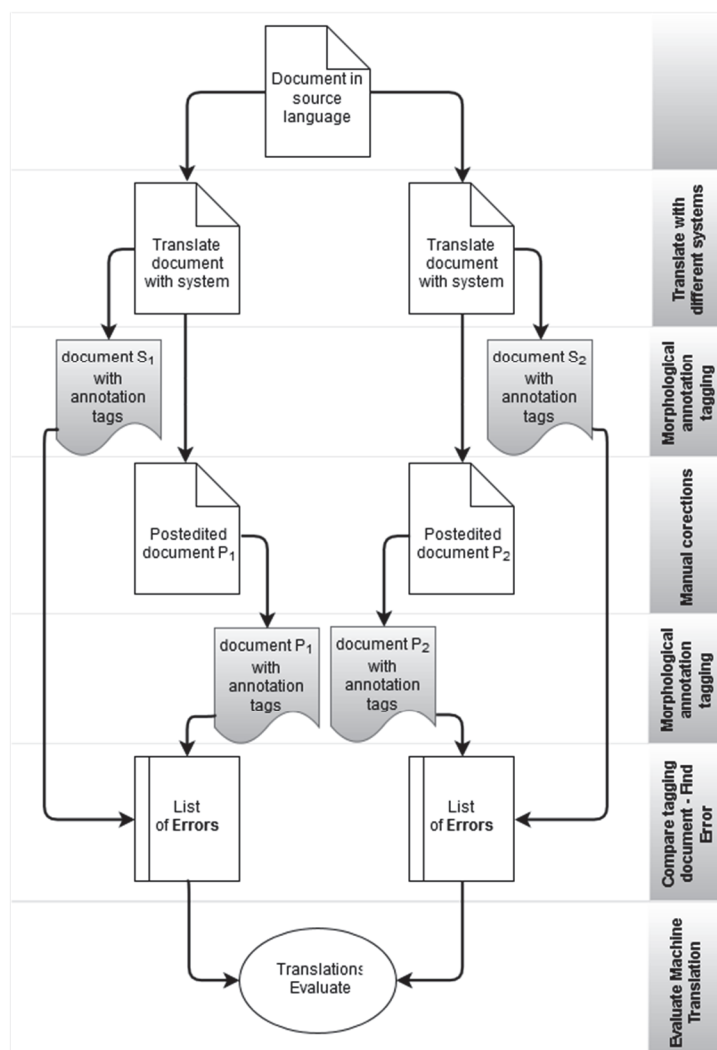


Figure 4: Illustration of procedure of MT error identification.

## CONCLUSION AND FUTURE DIRECTION

We presented a system for the evaluation of machine translation system through the translation quality assessment of machine translation output. The system consists of two sub-systems, one comprising manual evaluation of MT (post-editing) and manual error classification (post-editor has to classify occurred error into four defined categories); the second is focused on automatic classification of errors. By the text representation we arose from the transaction-sequence model which is described in (Munková, Munk and Vozár, 2013) and which was inspired by the work (Munk et al., 2015). We believe it will be useful not only for translation community (human or machine), but also for the community of natural language processing or philology.

## ACKNOWLEDGEMENT

This work was supported by the Slovak Research and Development Agency under the contract No. APVV-14-0336 and Scientific Grant Agency of the Ministry of Education of the

Slovak Republic (ME SR) and of Slovak Academy of Sciences (SAS) under the contracts No. VEGA-1/0559/14.

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# Quiz Module as a Tool to Activate Thinking During Lessons

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## **Abstract**

*There are many ways to activate students during lessons. When the computer technology in the classroom is also used, there are even more possibilities. In schools, a learning management system is often used as a repository for teaching and learning materials, or testing the students. However, such systems provide many opportunities for creative work with the students during the lesson. During our research, we used the learning environment Moodle, which is the most used, free and open-source software learning management system. The aim of the paper is to describe a methodology of the Quiz module using, included in the Moodle. This module is commonly used as a tool for testing the students or creating a self-test. We used this module as a tool to activate students during the lessons. The paper comprises theoretical basis of the issue of activating students during lessons. We described a method of using the Quiz module for activating students. Through this activity, students will not be engaged in the activities of the lesson individually, but collectively. This teaching method improves the impact on students' knowledge and motivation. The obtained data from the experiment are analysed. The aim of the article is mainly to inform readers about the possibility of using the module Quiz and motivate them to its similar use.*

## **Keywords**

*Educational data mining. Data analysis. Moodle. Activating learning methods. Quiz module.*

## **INTRODUCTION**

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The ever-growing area of research called Educational Data Mining (EDM) uses many different methods to analyse large amount of data. This data is collected in different ways, mostly from the electronic courses that provide log files containing details of the work of students or other users in this course. Systems, thanks to which we can easily create these courses and acquire data from them are called Learning Management Systems (LMS).

There are many LMS systems. Nowadays, one of the most commonly used is Modular Object Oriented Developmental Learning Environment (Moodle), a free learning management system enabling the creation of powerful, flexible and engaging online courses and experiences (Rice, 2006).

Moodle offers many different opportunities to provide information to students which we want to provide. They are different forms of modules, tests, dictionaries, other forms of study materials or more experienced course creators can also add animations, applets and the like. Each of these forms of information and diversity is intended to increase

students' interest in a teaching material and incentive to learning. And this will increase the effectiveness of teaching. These materials can be used in the classroom at school or to prepare for the lesson at home. These tools classroom should activate minds of students. And just in developing these tools it must be applied activating teaching methods. In the new educational system in the EU, a lot of emphasis is put on planning the quality of teaching and learning at the university level, and new activating learning methods have been introduced and tested (Rasila et al., 2007).

The aim of this paper is to show another way of using one of the modules of the LMS Moodle. It is called the Quiz module which is primarily and commonly used for testing the students. However, we used it as a tool for activating students' thinking during a part or a whole of the lesson.

The rest of the paper is structured as follows. The following section explains the importance of using an activating teaching methods and explains the concept. The third section deals with the Quiz module and its capabilities. The next section describes the methodology of using Quiz module and the implementation of our research. This section lists the results obtained. The last section provides the discussion and several ideas for the future research.

## **ACTIVE LEARNING**

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Active learning is what the student is doing in the classroom in addition to passive listening to teacher's explanation (Tomegová, 2012). During the active learning, higher mental operations from students are required. It means, that the students complete given assignments, answer the questions, write or discuss. The most important thing to active learning is not only that students actively work, but at the same time they think about what they are doing (Center for Teaching and Learning, 2012).

Development of social skills, independent thinking, independent learning and a strong sense of personal and collective responsibility are supported by students through active learning (Gullach, 2011). Activities supporting learning processes of students develop particular areas (Ginnis, 2005):

1. thinking,
2. emotional Intelligence,
3. independence,
4. interdependence,
5. many sensory perception,
6. the fun and joy from work,
7. articulation of learning content.

In order to fulfil the educational lesson objective through the own student cognitive activity, it is necessary to use activating teaching methods. Activating methods are (Kotrba and Lacina, 2007):

- encourage students' interest in learning,
- support intensive experiencing, thinking and action among students,
- use the acquired skills and knowledge of students,
- strongly support and develop the cognitive processes of students.

Classification of activating methods (Kotrba and Lacina, 2007):

1. the problem solving,
2. games,
3. discussion methods,
4. situation methods,
5. staging techniques and role play,
6. special methods.

We are mostly interested in the problem-based tasks that emphasize activity, productive thinking and independence of students. We divide difficult tasks on (Kotrba and Lacina, 2007):

- analysis of case studies,
- heuristic methods,
- black box methods,
- methods of confrontation,
- method of paradoxes.

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## **THE QUIZ MODULE**

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Quiz module, which Moodle contains, is mainly used for testing the users of electronic course. The module gives feedback based on the results of these tests. Using the Quiz module it is possible to create pretests, posttests, self-tests and so on. It consists of a large number of options, such issues can be presented to students, as well as many opportunities to respond.

There are many ways to use the Quiz module (Arenaza et al., 2014).

- Feedback about performance and self-assessment are important parts of a learning environment. There are several ways to give feedback to students: on each question or overall. The quiz module can display feedback and scores at different times during the quiz, using the review options in the Quiz settings.
- A wide variety of Quiz reports (in addition to Grades) are available for use by the teacher. Quiz reports not only can focus on a single student's attempt to answer each question, but also can perform a robust item analysis of a question's validity based upon aggregated student responses.
- A single quiz can automatically select random and/or specific questions from different categories of questions.
- There are different options for scoring.
- The quiz settings allow different display methods.
- The teacher can choose how the questions will behave during the test. It can be like a classic test, where the student gets no feedback while attempting the test, only later. But there is also the possibility of getting feedback immediately after answering the question. It is also possible to set that the student had more attempts to answer after a specific responses it is possible to give some help or other „message“ to student.

## **METHODOLOGY AND REALIZATION**

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In our experiment, during which we teach the subject Computer data analysis, we used the Quiz module for realizing the tests. We evaluated students based on these tests. Quiz module has also been used to create a self-test, so that students can test their knowledge continuously.

Subject Computer Data Analysis (CDA) is taught at the university. The CDA belongs to the compulsory subjects of bachelor study program and master study program of Applied Informatics in full-time and distance study while bachelor and master study program for teachers of academic subjects in full-time study and distance study (Reichel et al., 2015). The aim of this subject is to teach students of the Department of Computer Science to think statistically. On the subject students will learn basic statistical methods and how to use them in practice. Students learn especially with the help of case studies and word problems in practice. However, they are still students of informatics, not mathematics. Statistics is an area in which the student needs to mathematical thinking. Therefore, we say that we teach mathematics nonmathematicians (Reichel et al., 2015).

On a few lessons we used Quiz module in a specific way. The aim of this paper is to describe the method of using the module Quiz.

In the chapter Active learning, we described the reasonable use of activating methods for lessons. We just used the Quiz module for activating students not only during the filling of the self-test or any other test. Quiz module allows students to ask questions in different ways. The questions that are asked to students during lessons (while explaining the new curriculum and the like) force students to think actively, not just passively listening to a lecture. If during normal lesson to ask a question with a concrete response to the whole class, it can practically respond to only one student, who you called out. This is why many students do not respond to questions and leave the answer to classmates. However, if students are sitting at the computer, it is possible to involve every student. We can do it easily by applying Quiz module.

We have implemented this methodology for the lesson where you explained how to analyze case studies in progress. Case study consists of concrete phases that can not be skipped. Therefore, the lesson had to be strict sequence. This allowed us to create a "test" in the Quiz module that was not the real test, but kind of tool which allowed us to gradually ask students current questions. The lesson took place so that we have explained part of the curriculum and then we asked students a question that was related to the explained part of the syllabus or to part of the syllabus that will follow. This issue was detailed in tests, for example as a Question 1. The purpose of the questions may be, for example verifying whether students understand the explanation part of the curriculum, or if the question was directed to knowledge, have not yet been explained, we verify what students have in the field survey.

In the Quiz module it can be set so that students are not able to go back to the previous question. So if we put the question to students and each of the students will answer at the moment, it is possible to analyze these responses later. So if we explain some issues to students and then we ask the question this way and we will look at the analysis that 90% of students answered incorrectly, it means that either the students were inattentive or issue has been poorly explained. This method can be very good feedback for the teacher.

Quiz module offers many opportunities to ask questions. You can ask questions with multiple choices, where are one or more correct answers, which can be in the form of text or images. Another option is the text or numeric answer, sort option answers, joining into pairs and many others. If one particular error occurs frequently on some questions, we can analyze why this error occurs and the next time of using module we can set the system to advise to student what he did wrong, if the reports this error.

Lessons where we want to stimulate the activity of all or most students in this way, need a careful preparation. There is a need to rethink the overall sequence of lessons to sequence your questions in the test corresponded with your lectures.

We implemented methodology during two semesters on lesson on the topic of Evaluation of data preparation for web log mining: Case study on the subject CDA. The case study is focused on data preparation in the process of knowledge discovery, namely to address the problem of evaluation of basic steps for data preparing for web log mining. The aim was to find out what is the extent to which it is necessary to realize data preparation for web log mining with an emphasis on data cleansing and determine the necessary steps to obtain reliable data from the log file (Munk et al., 2013).

Case study methodology (Munk et al., 2015; Munk et al., 2010):

1. Data acquisition from log file web server.
2. Preparation of the data at four different levels:
  - a. set 1: adjusted data from unnecessary data / requests for images, scripts and styles - raw data,
  - b. set 2: adjusted data from unnecessary data and different robots,
  - c. set 3: adjusted data from unnecessary data, accesses of robots and NAT / proxy devices,
  - d. set 4: adjusted data from unnecessary data, accesses of robots and the identification of sessions based on time.
3. Data analysis - looking for patterns of behaviour of web users in individual files.
4. Understanding output data - creating a data matrix of outcomes analysis.
5. Comparison of the results of the data analysis that are processed at a different level of data preparation in terms of quantity and quality found sequence rules of behaviour of users when browsing the web:
  - a. comparison of the proportion of rules found in the studied sample,
  - b. comparison of the values of support and confidence of rules found in the studied sample.

The table, which can be exported from Moodle contains any attempt in the test of the students. This means that the table contains the error opening the module or its closure. It was necessary to cleanse the data from these attempts. The lesson takes about 90 minutes and we used the Quiz module 30 to 45 minutes. It was therefore necessary to remove the attempts that were too short (typically a few seconds to minutes) or too long (typically several days). It is possible to prevent the attempts that were too long, use time limit of the attempts in Moodle. It was also necessary to remove the attempts which were made outside lesson time because we want to analyze data on the behaviour of students during lessons.

Surname	First name	Email address	State	Started on	Completed	Time taken	Grade/10.0	Q. 1 /0.77	Q. 2 /0.77	Q. 3 /0.77	Q. 4 /0.77
Štoko	Viktor	viktor.stoko@stud	Finished	25 november 2013	25 november 2013	35 mins 31	7,18	0,26	0,26	0	0,7
Undrůs	Ján	jan.undrus@stud	Finished	25 november 2013	25 november 2013	37 mins 16	9,23	0,77	0,77	0	0,7
Holečová	Mária	maria.holecova@stud	Finished	25 november 2013	25 november 2013	36 mins 14	8,72	0,26	0,26	0,77	0,7
Švec	Gabriel	gabriel.svec@stud	Finished	25 november 2013	25 november 2013	35 mins 40	7,18	0,77	0,26	0	0,7
Motovsky	David	david.motovsky@stud	Finished	25 november 2013	25 november 2013	36 mins 50	6,92	0,77	0,26	0	0,7
Zemková	Jaroslava	jaroslava.zemkova@stud	Finished	25 november 2013	10 december 2013	15 days 1	8,21	0,77	0	0,77	0,7
Šubý	Lukáš	lukas.suby@stud	Finished	25 november 2013	25 november 2013	37 mins 51	7,44	0,26	0,26	0	0,7
Undrůs	Martina	martina.undrus@stud	Finished	25 november 2013	25 november 2013	36 mins 16	8,46	0,26	0,77	0	0,7
Lešná	Lucia	lucia.lesna@stud	Finished	25 november 2013	25 november 2013	35 mins 53	6,15	0	0,26	0	0,7
Paulík	Juraj	juraj.paulik@stud	Finished	25 november 2013	25 november 2013	36 mins 14	8,46	0,77	0,26	0	0,7
Podst	David	david.podst@stud	Finished	25 november 2013	25 november 2013	36 mins 58	8,97	0,77	0,77	0	0,7
Kozmý	Ladislav	ladislav.kozmy@stud	Finished	25 november 2013	25 november 2013	36 mins 52	8,46	0,77	0,26	0	0,7
Škapitová	Zuzana	zuzana.skapitova@stud	Finished	25 november 2013	25 november 2013	36 mins 2	7,44	0,26	0,26	0	0,7
Čížek	Roman	roman.cizek@stud	Finished	25 november 2013	25 november 2013	35 mins 45	8,46	0,77	0,26	0	0,7
Heřm	Michal	michal.heřm@stud	Finished	25 november 2013	25 november 2013	35 mins 56	7,95	0,77	0,26	0	0,7
Oborný	Juraj	juraj.oborny@stud	Finished	25 november 2013	25 november 2013	35 mins 48	10	0,77	0,77	0,77	0,7
Lucinská	Jana	jana.lucinska@stud	Finished	25 november 2013	25 november 2013	36 mins 16	8,72	0,77	0,26	0,77	0,7
Blahosť	Mária	maria.blahost@stud	Finished	25 november 2013	25 november 2013	35 mins 32	7,69	0,77	0,26	0	0,7
Víteček	Tomáš	tomax.vitecek@stud	Finished	25 november 2013	25 november 2013	35 mins 24	8,46	0,77	0,77	0	0,7
Poněšný	Lucia	lucia.ponesny@stud	Finished	25 november 2013	25 november 2013	35 mins 25	7,69	0	0,26	0	0,7
Čermáková	Jarmila	jarmila.cermakova@stud	Finished	25 november 2013	25 november 2013	33 mins 20	9,23	0,26	0,51	0,77	0,7
Štěrba	Stanislav	stanislav.sterba@stud	Finished	27 november 2013	28 november 2013	0 hours 50	5,0	0,51	0	0	0,7

Figure 1: The exported data on the behavior of students (raw data).

In the figure 1 you see the score, what students gained. It is their score of the final test at the end of the semester. They were tested on their knowledge of the subject CDA. Since our "test" contained 13 questions Moodle recalculated gained students score to number of points out of ten. We gain a clearer score by easily multiplied by 1.3.

Surname	First name	Class	Year	Quiz grade	Relative score	Total	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
Čermá	Lucia	14_1	14 B		84,62	11	1	0,3	1	1	1	1	0	1	1	0,7	1	1	1
Gyuranová	Kristína	14_1	14 D		66,92	8,7	1	0,7	1	0	1	1	0	1	0	1	1	0	1
Kurka	Marián	14_1	14 D		66,92	8,7	0,7	0,7	1	1	1	1	0	1	1	0,3	0	0	1
Maršálka	Boris	14_1	14 D		69,23	9	0,7	0	1	0	1	1	1	0	1	0,3	1	1	1
Maršej	Marián	14_1	14 D		66,92	8,7	0,7	0,3	1	0	1	1	0	0	1	0,7	1	1	1
Mindiek	Ondrej	14_1	14 FX		38,46	5	1	0	0	1	0,7	0	0	0	1	0,3	0	1	0
Miroslav	Miroslava	14_1	14 B		86,92	11,3	1	0,7	0	1	1	1	1	1	1	0,7	1	1	1
Poněšný	Martin	14_1	14 C		71,54	9,3	0,3	0,3	1	1	1	1	1	0	1	0,7	1	0	1
Seman	Lubomír	14_1	14 D		61,54	8	1	0,7	0	1	0,7	1	0	0	1	0,7	0	1	1
Sider	Peter	14_1	14 C		71,54	9,3	1	0,7	1	1	1	1	0	0	1	0,7	1	0	1
Šablon	Darko	14_1	14 B		84,62	11	1	1	0	1	1	1	1	1	1	1	1	0	1
Šolky	Tomáš	14_1	14 E		53,85	7	0,3	0,3	0	1	1	1	0	0	1	0,3	0	1	1
Imka	Anton	14_1	14 C		74,62	9,7	0,7	0	1	1	1	1	0	1	1	1	1	1	0
Varlová	Veronika	14_1	14 A		92,31	12	1	1	1	1	1	1	1	1	1	1	1	0	1
Zečňák	Tomáš	14_1	14 C		71,54	9,3	0,7	0	1	1	0,7	1	1	0	1	1	1	0	1
Štubňová	Michaela	14_1	14 C		71,54	9,3	0,7	0	0	1	1	1	1	0	1	0,7	1	1	1
Antacký	Tomáš	14_2	14 A		90,00	11,7	0,7	0,3	1	1	1	1	1	1	1	0,7	1	1	1
Ilábo	Mário	14_2	14 D		69,23	9	1	0,3	0	0	1	1	1	1	1	0,7	0	1	1
Ilutka	Zdenko	14_2	14 D		66,92	8,7	1	0,3	1	1	1	1	0	1	1	0,3	0	0	1
Iludec	Mário	14_2	14 C		74,62	9,7	1	0,3	0	1	1	1	1	1	1	0,3	0	1	1
Kostlont	Adrián	14_2	14 FX		48,46	6,3	0	0	1	0	0,7	1	0	0	1	0,7	1	1	0

Figure 2: Adjusted exported data on the behavior of students - Added category.

In the table, we also added a group identifier (class), in which the student was. Furthermore, we have added year, the relative score that a student received and grade by which we can divide students into groups based on success. Applicable data were from 85 students after data cleaning. Student's grade was calculated using the percent (>90% = A, 90% > B > 80%, etc. 10% more). Based on the grades we divide the students into groups and generated pivot table according to years.

Pivot table (Table 1) shows the results of the first year are better than results of later year. This is probably due to the fact that this methodology was not sufficiently optimized at the first attempt. The problem was mainly that many students incorrectly understood the meaning of this "test" and often answered later than they should. Grades of students

that have been generated on the basis of their answers in this quiz were not considered in the final grades. Quiz grades are only for purposes of this experiment, to analyse the behaviour of students during this activity and to verification of students' knowledge. The fact that students from the first year of the experiment did not clearly explained whether this activity will be evaluated in the final grade meant that students have pointed response after the explanation of the correct answer. In the second year we eliminated this bug of teacher and therefore the results are more accurate. This can be seen in Table 2. This table shows the relative score of Quiz in this "test". Group names are generated by the key: the first two numbers reflect the year and the third number is the order in which this activity was carried out in a group. In year 13 we can see that the relative score of the second group decreased and the third group had a relative score extremely high. The 14 year already we see a gradually increasing score. The results of 2013 are more heterogeneous compared to 2014. We suppose it was caused by a gradual optimization of ways of explaining and by related a gradual adjustment of lesson on the basis of students' reactions. In 2014 we were able to better apply the described methodology based on our experience.

As mentioned, the grades obtained by the students on the basis of described activity, were not considered in the final evaluation. But these data provide us some image about the particular student. We evaluated students using summative and formative methods. The final grade of activity was calculated using the relative scores that students gained for a response in the Quiz module during a lesson. Also, we have asked students to each question, what was their answer. Based on the number of correct answers from the current issue, we adapted a form of explanation. When it was obvious that many students could not answer correctly, we further explain the issue. If all or almost all of the students were able to answer correctly, the explanation was concise. This procedure also depends on the course of the lesson and the students' attention. Mentioned formative assessment and verification of students' answers could be optimized through direct electronic monitoring students' answers. By this we would achieve that it is not necessary to additionally verbally ask students.

Table 1: Pivot table of students' Quiz grades.

Year/Quiz grade	A	B	C	D	E	FX	Row totals
13	11	14	14	3	2	0	44
14	3	8	13	12	3	2	41
<b>Column totals</b>	14	22	27	15	5	2	85

Table 2: The relative score of Quiz ordered by groups.

Group	13_1	13_2	13_3	14_1	14_2	14_3
Relative score of Quiz	81.38462	76.7033	89.38462	70.81731	71.07692	73.23077

The following table (Table 3) shows the results of usage analysis of electronic course (Munk and Drlík, 2014). In the Table 3, we can see that the Quiz module has the most support (49.5%). Activity Quiz mainly contained self-tests and also was used to activate the students during the lessons. The modules pairs with the highest support are (Quiz, Assignment), (Resource, Assignment), (Quiz, Book), (Book, Assignment), (Book, Resource) and (Quiz, Resource). Other combinations have not more support than 1%.



Table 3: Support of the selected modules and their pairs.

Frequent itemsets	Support (%)
( quiz )	49.52978
( assignment )	32.82759
( book )	22.10658
( resource )	12.07524
( feedback )	2.33229
( user )	1.02821
( quiz, assignment )	5.00313
( resource, assignment )	4.89028
( quiz, book )	3.51097
( book, assignment )	3.13480
( book, resource )	2.95925
( quiz, resource )	2.87147

High support of Quiz module is mainly caused by a combination of encouraging frequent use of self-test in the course and described activating learning method that uses this module. Combinations (Quiz, Assignment), (Quiz Book) and (Quiz Resource) have high support due to the fact that students were often forced to use self-tests, in which they used the assignments. Similarly, in the above-described method of using Quiz module, students had the opportunity to use the resources in a course, means activity Book, Resource or finished assignments in the Assignment module. Examples of case studies have been stored in the electronic course also in PDF format, so we assume that students study also these materials during lesson.

## CONCLUSION

In this paper we described a new and specific method of Quiz module using, which is a module of the Moodle learning environment. We have described the meaning of this way of using of the Quiz module to optimize and improve a teaching using the electronic course. The description and brief analysis can help other educators to improve the methodology and adapt it into different study subjects.

We have described the possibilities of the Quiz module and ability to use it as an activating element of the lesson. The methodology is based on continuous questioning the students, which is a common practice in the lessons. With the help of this module and the methodology described above, we can activate thinking of all students who are presented in the lesson. This means that there will not be engage to only one student who was called out and who wants to answer the teacher's questions. This method, in contrast to classical oral questioning, makes it possible to analyse the speed, activity, knowledge and skills of students during the lesson or immediately after the lesson by analysing the acquired data. Equally, it gives excellent feedback to the teacher. Usage analysis showed that the module Quiz had the greatest versatility in our course.

In the paper, it was no space for a deep qualitative analysis of the individual students. However, this methodology provides a space for this analysis. Based on the data, collected over two years, we realised a quantitative data analysis with a discussion of the feedback. From the pivot table we received information about the increasing trend in the relative score of students during the year 2014. We suppose that it was due to optimization of the teaching methodology.

The following research on virtual education should be strongly based on the research how to activate and motivate the students. The methodology described in this paper can be further explored depending on the evaluation of students of similar activities and their outcome assessment. Research of methods of qualitative data analysis can also have great benefits.

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# Impact of the Use of Activating Educational Methods Using Moodle on the Effectiveness of Teaching and Statistical Literacy

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## Abstract

*One of the most important factors, that influence the effectiveness of teaching, is to motivate student to learn. The student learns the most when he is forced to actively think. Therefore, it created activating teaching methods that are continuously improved. Using these methods, student must actively think during the lessons. This paper aims to verify whether the use of activating teaching methods applied by an electronic learning environment of course created in Moodle has a positive effect on activation of students thinking and thus on improve of the teaching process. Research was conducted on the subject Computer data analysis. It is a subject which aim is to teach students to work in statistical software and understand the relationships that are used when working with it. Another aim of our research was to verify whether such a method of teaching of Computer Data Analysis impact on students' statistical literacy. Since the experimental group pretest results differed from the results of the control group, it must be analysed using the analysis of covariance, which "equalizes" the results of the pretest in both groups. Based on this analysis, we verified that teaching through activation of students thinking using Moodle has a positive effect on overall student performance and also on the effectiveness of teaching. The analysis, however, refuted the claim that the teaching of Computer Data Analysis with the help of activating teaching methods had a significant impact on students' statistical literacy.*

## Keywords

*Experimental data analysis. Analysis of covariance. Moodle. Activating students.*

## INTRODUCTION

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For more effective teaching of mathematics, there are many different methods. The most effort is to motivate students. Activating teaching methods serve the purpose intended to activate the thinking of students during lessons. Educational lesson objective is pursued by means of educational activity of students through these methods (Kotrba and Lacina, 2007). Activating learning methods temp to inspire students who are already interested in qualitative learning (Pietikainen and Zitting, 2009).

The tool that we have used for activation of students, is the Learning Management System. Nowadays, one of the most commonly used is Moodle (Modular Object Oriented

Developmental Learning Environment) which is a free learning management system that enables the creation of powerful, flexible and engaging online courses and experiences (Rice, 2006).

During semester we have taught the subject Computer Data Analysis (CDA) using the course (Reichel and Kuna, 2014). The course is mainly focused on data mining and statistics. We created an experimental and a control group. Enrolled students were not students of mathematics, we can say that it was teaching mathematics for non-mathematicians. The experimental group (48 students) used a course that included more activating elements, and students were encouraged to use these elements during the lessons. The control group (20 students) used a simple course that contained only materials in pdf format. CDA course of experimental group contains several activities that allows the use of modules in Moodle. These are the study materials in the form of modules Book or Quiz (self-tests). The main activating element is a specific application of module Quiz, which was used during several lessons to engage students in the affairs of the lesson.

The aim of this research is to verify whether the use of activating educational methods developed with the help of Moodle has a positive impact on the effectiveness of teaching and whether the use of such methods during statistics lessons has an impact on statistical literacy of students.

Wang and Yu investigated the effect of interactive e-learning on motivation and performance in mathematics (Wang and Yu, 2015). They compared the traditional way of teaching and quasi-experimental mode to another group of students. The experiment was applied to elementary school students in Chiayi County. In the analysis, there was used t-test and ANOVA. With these tests, they compared the results of the pretest and posttest. It was found a statistically significant difference in student achievement, confirming that the use of e-learning increased student motivation.

Nunez et al. tested self-regulatory strategies in education with the help of a virtual environment (Nunez et al., 2011). They analyzed obtained data from the Moodle, which was used as an educational environment at the University of Oviedo. Study was semi-experimental designed using a pretest and posttest. Students, who participated in the training program (experimental group) showed better results compared to students in the control group.

Scientific papers dealing with the effectiveness of e-learning was published by (Hubalovsky and Sedivy, 2011; Turcani and Magdin, 2012; Kasparova and Krupka, 2014; Poulova and Klimova, 2015).

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## **METHODS**

Analysis of covariance (ANCOVA) is a General Linear Model, which combines elements of analysis of variance, and multivariate regression. One or more quantitative factors - covariates / covariance variables are added to the model of analysis of variance, which examines the dependence of intensive/quantitative variable on the nominal factors. The regression model of analysis of covariance in the case of two groups and one covariance variable  $x$ :

$$Y_i = \beta_0 + \beta_1 x_i + \beta_2 z_i + \beta_3 x_i z_i, \quad (1)$$

where  $z$  denotes the value of the indicator - dummy variable. This variable has a value of 0 or 1 depending on whether it was measured in the first group or in the second. The  $\beta_2$  coefficient reflects the effect of the nominal factor. The  $\beta_1$  coefficient evaluates the impact of covariance variable. The  $\beta_3$  coefficient stands for the presence of the interaction between the covariate and nominal factor.

If the relationship between  $X$  and  $Y$  is significant, the model of covariance analysis explains more variability of the variable  $Y$  than a model of analysis of variance. Analysis of covariance tests whether the adjusted means of groups are different. The means are designed as if the same (average) value of intensive / quantitative factor is in all groups.

## RESULTS

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The aim of our research was to find out whether our method of teaching with the support of the CDA has a positive impact on student achievement. Therefore, research was realized. We chose experiment as a research method and didactic test as a research tool, namely Pretest CS, Posttest CS, Pretest SL and Posttest SL. These tests are focused on computational statistics (CS) and statistical literacy (SL).

Research hypotheses imply a positive impact on student outcomes in terms of knowledge acquired from computational statistics and in terms of the development of statistical literacy:

- a. Activation of students through activities CDA course is didactically effective, increasing attention and activation of students through the course CDA have statistically significant impacts on student performance in computational statistics.
- b. Activation of students through activities CDA course has a positive effect on the development of statistical literacy, increasing attention and activation of students through the course CDA have statistically significant impacts on the development of statistical literacy of students.

The procedure for conducting research:

1. Draft an experimental plan – the creation of control and experimental groups.
2. The creation of reliable and valid educational tests.
3. Realization of experimental plan.
4. Set up a statistical null hypothesis.
5. Verification of validity - the assumptions of using analysis of covariance.
6. Hypothesis testing and interpretation of results.

After the realization of an experimental plan we obtained the pretest and posttest results of the experimental and control groups. The score from the individual didactical tests was recorded of each student. In the pretests (posttests), student could get a maximum of 10 (10) points.

Table 1: Descriptive Statistics for Covariate Pretest CS

	Level of Factor	N	Pretest CS Mean	Pretest CS Std. Dev.	Pretest CS Std. Err	Pretest CS -95.00%	Pretest CS +95.00%
Total		65	4.340	1.475	0.183	3.975	4.706
Group	exp	45	4.398	1.547	0.231	3.933	4.863
Group	con	20	4.210	1.326	0.296	3.589	4.830

Table 2: Descriptive Statistics for Dependent Variable Posttest CS

	Level of Factor	N	Posttest CS Mean	Posttest CS Std. Dev.	Posttest CS Std. Err	Posttest CS -95.00%	Posttest CS +95.00%
Total		65	6.331	1.593	0.198	5.937	6.726
Group	exp	45	6.598	1.316	0.196	6.203	6.993
Group	con	20	5.732	1.998	0.447	4.797	6.667

Table 3: Descriptive Statistics for Covariate Pretest SL

	Level of Factor	N	Pretest SL Mean	Pretest SL Std. Dev.	Pretest SL Std. Err	Pretest SL -95.00%	Pretest SL +95.00%
Total		64	3.763	1.684	0.211	3.342	4.184
Group	exp	44	4.062	1.866	0.281	3.494	4.629
Group	con	20	3.106	0.932	0.208	2.669	3.542

Table 4: Descriptive Statistics for Dependent Variable Posttest SL

	Level of Factor	N	Posttest SL Mean	Posttest SL Std. Dev.	Posttest SL Std. Err	Posttest SL -95.00%	Posttest SL +95.00%
Total		64	3.931	2.038	0.255	3.422	4.440
Group	exp	44	4.074	1.704	0.257	3.556	4.592
Group	con	20	3.618	2.655	0.594	2.375	4.860

Tables (Tab. 1-4) contain a point and interval estimation of average, standard deviation and standard error estimation of the average of pretest and posttest scores for both groups and for each group separately.

From the descriptive statistics (Tab. 1-4) we can say that not only the differences in posttest score may affect the results of posttest, but also the pretest scores. Based on these results, we need to verify the validity of the following statistical null hypothesis. We have to verify it for the results of the tests to test the knowledge (a) and also for the statistical literacy (b):

1. H0: The relationship between pretest and posttest is not statistically significant.
2. H0: There is no statistically significant difference in posttest scores between the experimental and control group with control of pretest variable.

If we reject the first hypothesis, the analysis of covariance model explains variability of posttest variable more than analysis of variance model. If we reject the second hypothesis, it would confirm our research hypotheses (a) and (b), due to better means of posttest score obtained in the experimental group.

We chose the analysis of covariance to test the above hypothesis. Before we use this method, we must verify the conditions of its use. For the analysis of covariance there must be fulfilled the conditions of analysis of variance, i.e. normal distribution of dependent variable in each group and equality of variances.

We verified the assumptions of normality through categorized normal probability plot. There were identified only slight deviations from normality. Therefore, we used the non-parametric Levene's test and Sen-Puri non-parametric test to test the assumption of equality of variances and homogeneity of variance-covariance matrices. The hypothesis of equal variances was not rejected ( $p < 0.05$ ) for any of the cases, i.e. there had been no violation of assumption.

Limiting assumption of using analysis of covariance is the condition - the regression coefficient  $\beta$  is the same in all groups. This condition is often violated, which limits the use of analysis of covariance. Significant interaction of interval and nominal factor is a breach of this condition. Then different means of groups depend on the interval factor. The easiest way to verify this condition is to check categorized correlation graph for each level of the factor (Fig. 1-2).

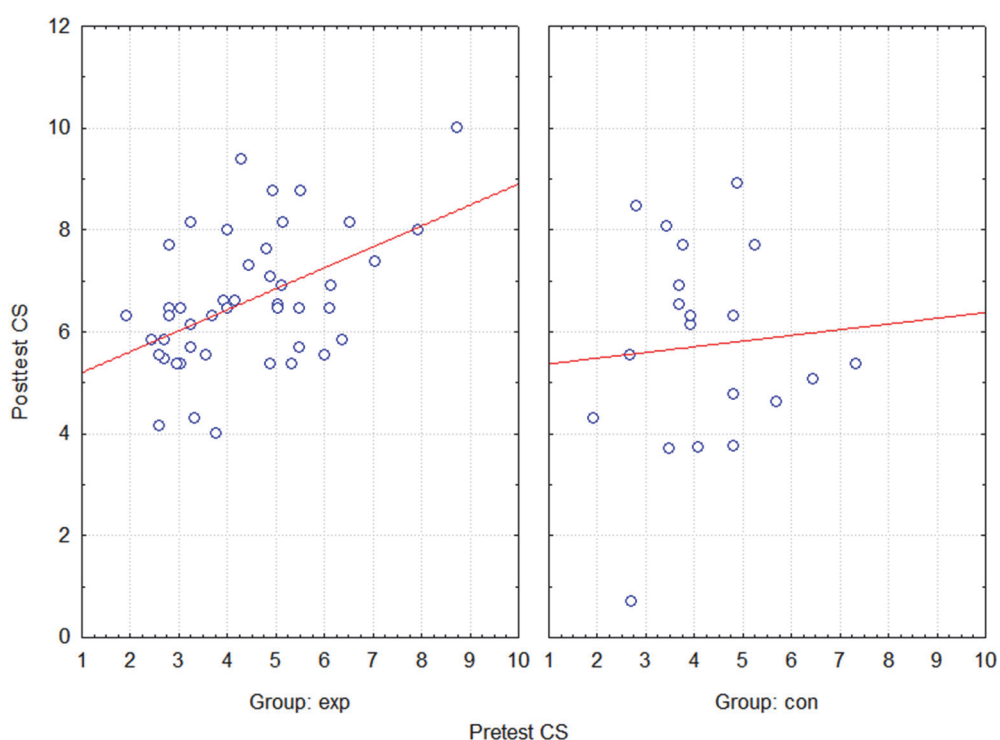


Figure 1: Scatterplot of Posttest CS against Pretest CS categorized by Group



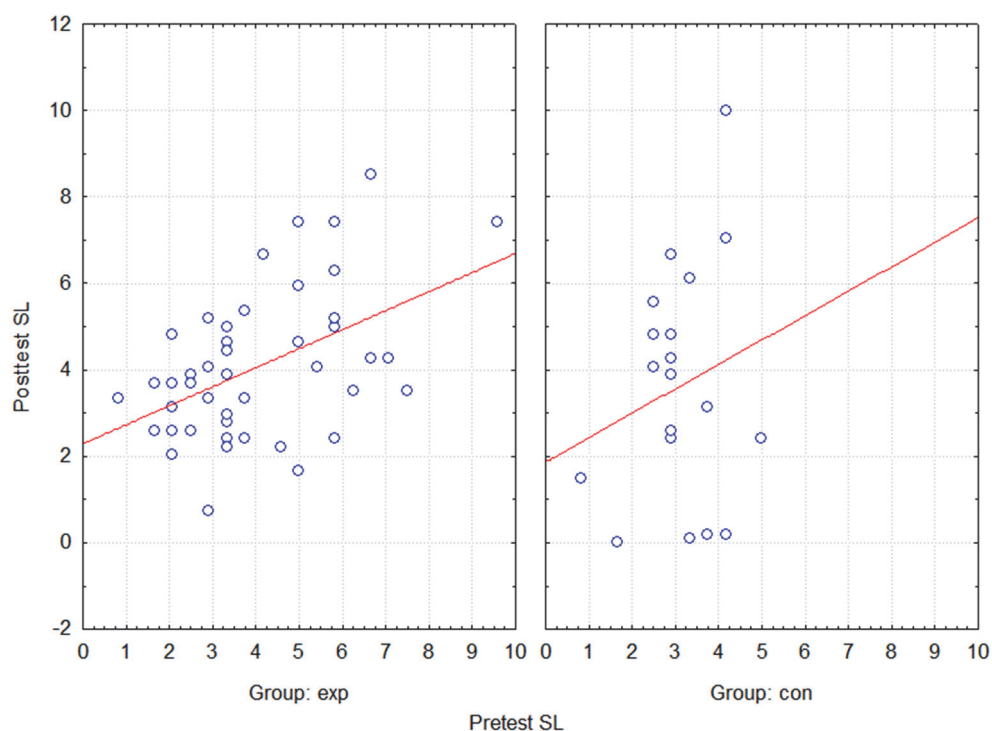


Figure 2: Scatterplot of Posttest SL against Pretest SL categorized by Group

The quantitative factor - the covariate is on the horizontal axis and the dependent variable is on the vertical axis. If individual lines have approximately the same slope, the condition is met. The lines are similar (Fig. 1-2), e.g. the regression coefficient is approximately the same in both groups.

We used analysis of covariance to analyse data type of pretest-posttest, which is considered as an optimal approach to the analysis of experimental data. The analysis was performed at the posttest results as the dependent variable, while a pretest represents a covariate.

Table 5: Analysis of Covariance for Dependent Variable Posttest CS

	Degr. of Freedom	Posttest CS SS	Posttest CS MS	Posttest CS F	Posttest CS p
Intercept	1	146.0852	146.0852	66.5558	0.0000
Pretest CS	1	15.9447	15.9447	7.2643	0.0090
Group	1	8.8643	8.8643	4.0385	0.0488
Error	62	136.0855	2.1949		
Total	64	162.4029			

Table 6: Analysis of Covariance for Dependent Variable Posttest SL

	Degr. of Freedom	Posttest SL SS	Posttest SL MS	Posttest SL F	Posttest SL p
Intercept	1	51.8508	51.8508	14.0693	0.0004
Pretest SL	1	34.0064	34.0064	9.2274	0.0035
Group	1	0.0074	0.0074	0.0020	0.9644
Error	61	224.8080	3.6854		
Total	63	261.6810			

Tables (Tab. 5-6) show, that the relationship between the covariate / controlled variable Pretest CS (Pretest SL) and the dependent variable posttest CS (posttest SL) is statistically significant at the 0.01 level of significance, i.e. analysis of covariance model explains more variability of the dependent variable than the model of analysis of variance.

We reject the null hypothesis (Table 5), which claims that the difference of posttest CS scores between experimental and control groups with control of pretest CS score is not statistically significant, i.e. dependent variable Posttest CS depends on the factor Group.

Conversely, in the case of statistical literacy, we do not reject the null hypothesis (Tab. 6), i.e. dependent variable Posttest SL does not depend on the factor Group.

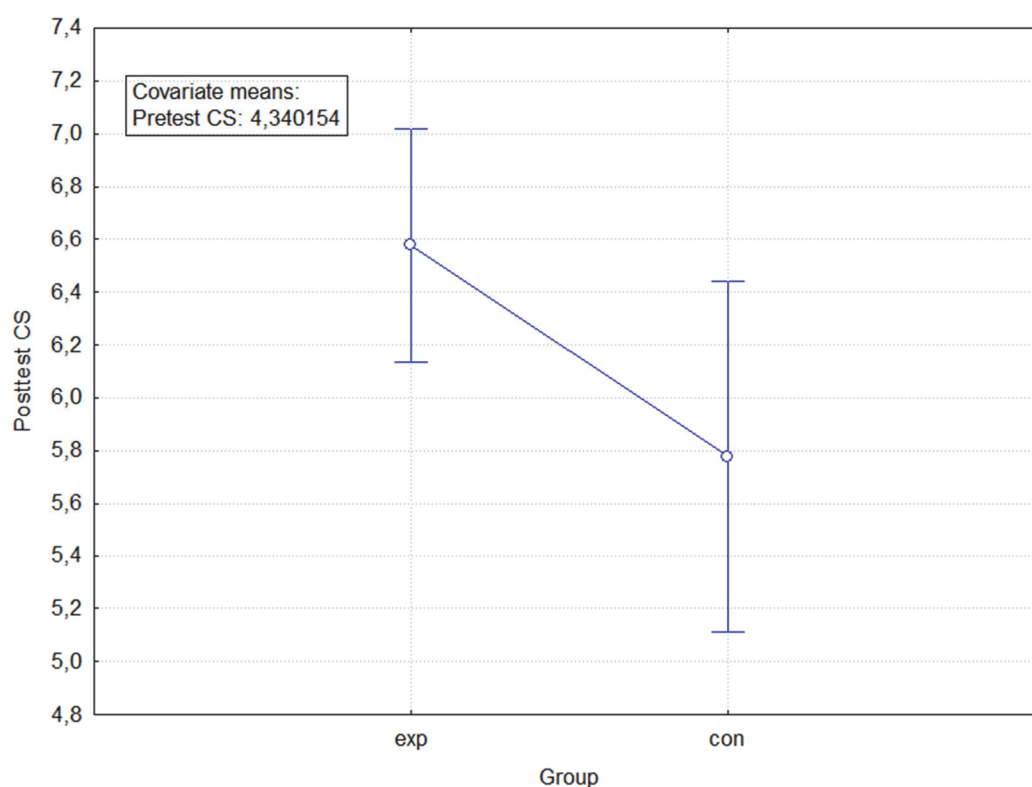


Figure 3: Means with Conf. Intervals Plot of Posttest CS

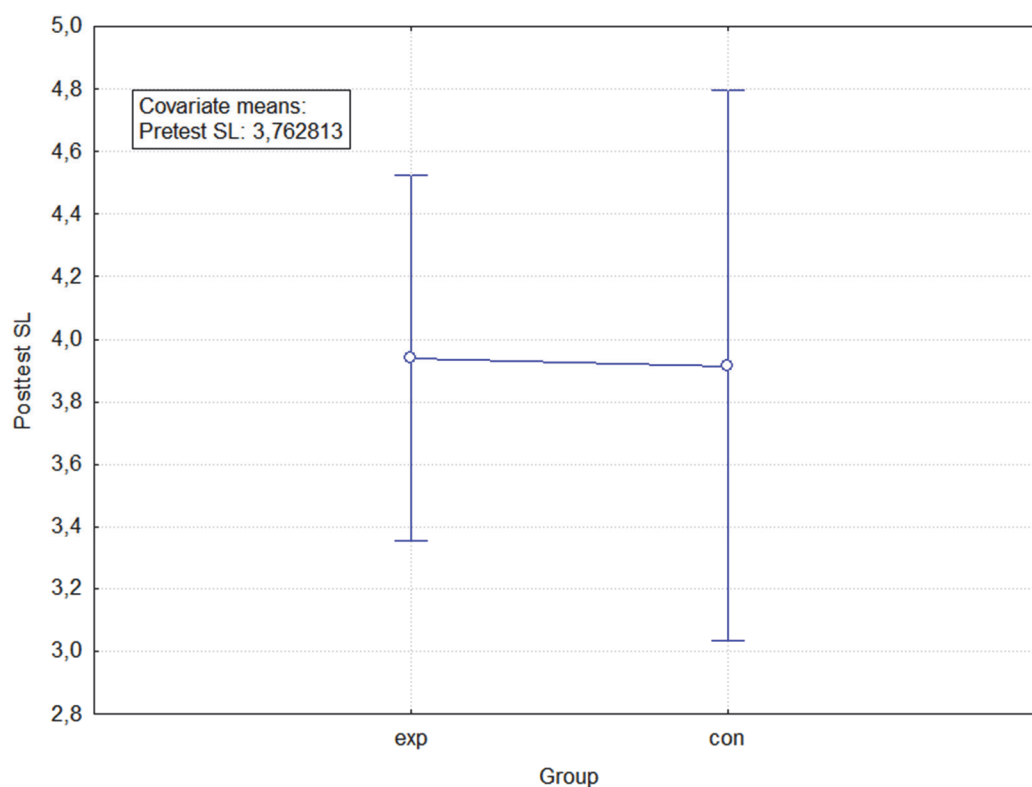


Figure 4: Means with Conf. Intervals Plot of Posttest SL

Charts (Fig. 3-4) visualize the adjusted averages of groups. Averages are treated as if the value of covariate Pretest was the same in all groups. The charts show point and interval estimation of the average of Posttest CS score (Posttest SL) in both groups with respect to the difference of Pretest CS (Pretest SL) score.

## CONCLUSION

We verified the research hypothesis (a) and (b) using the previous analysis, i.e. we have shown that activation of students through the CDA course activities is didactically effective. On the contrary, its positive effect on the development of statistical literacy was not confirmed.

We verified the validity of statistical tests in order to reduce their power. We used analysis of covariance to address the research problem, its usage is limited by the assumption of concordance of regression of posttest with pretest in the individual groups. If the assumption of equality of regression coefficients is not met, covariates can be divided into categories, and we can also add obtained factor to the analysis of variance. Thereby we transform analysis of covariance into two-factor analysis of variance. On the other hand, the interpretation is less valid when there are differences in pretest between the groups.

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Poľnohospodárske družstvo

Title: **DIVAI 2016 - 11<sup>th</sup> International Scientific Conference on Distance Learning  
in Applied Informatics**

Subtitle: Conference Proceedings

Publisher: Wolters Kluwer

Edition: 2422

Editors: Milan Turčáni, Zoltán Balogh, Michal Munk, Ľubomír Benko

Cover Design: Peter Švec

Format: B5

Year: 2016

Place: Prague

Pages: 608

Copies: 80

ISBN: 978-80-7552-249-8

ISSN: 2464-7470 (Print)

ISSN: 2464-7489 (On-line)

ISBN 978-80-7552-249-8





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**ISBN 978-80-7552-249-8**

**ISSN 2464-7470**

ISBN 978-80-7552-249-8



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