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Let's explore new ways

Dear authors and readers.

Authors′ interest to publication in the ICTE Journal sharply increased in this year. The six of expert articles in the current issue is proof of that. We know that the quantity is not the only one indicator of success of our journal. Quality is and will be much more important indicator than quantity, not only for us but also for our readers. We will continue to keep our mission: to mediate new findings and approaches of experts in the field of ICT application. We want to try with you to find new ways in order that modern gadgets does not become just an expensive toys in schools, but effective tools in support of education. And what articles you can find in the current issue?

The author of the first article asks, how to increase students' activity when performing simulations of electronic systems. During the computer simulation experiments often becomes that better students meet the targets and achieve the intended educational objectives earlier than the teaching time planned for this activity expires and the teacher has to deal with this situation.

The topic of the second article is informatics education, concretely current state and perspectives of development within the system of field didactics in the Czech Republic. Authors formulate the current problems that informatics education will have to tackle and indicate the possible dangers and perspectives of its future developments.

The third article focuses on didactics of programming. The serious problem is that future teachers do not differentiate between levels of complexity when trying to teach various programming topics, or they skip important steps when explaining solution of a problem.

Readers of the fourth article get to know more about programming with motion sensor using LEGO WeDo at lower secondary school. The authors identified, what types of activities the pupils resolved correctly and in what types of activities pupils most often made mistakes, and suggested solutions.

The fifth article discusses the learner-content interaction in flipped classroom model. The article presents the results of a six-month research of the experimental teaching of mathematics during which students watch educational instructional video before school lessons.

In the sixth article, readers will find a wide range of really very interesting information about the quality of higher education and structure of ICT competence of teachers in Ukrainian high schools. The topic “mobile learning” cannot possibly miss in the journal about ICT in education in the year 2015, therefore the appendix is about Ipads in education that should be teachers’ effective tool in frontal education.

So readers read, writers write and all together look for not only new, but also really efficient ways to use ICT in education.

Pavel Kapoun
Executive Editor

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HOW TO INCREASE STUDENTS' ACTIVITY WHEN PERFORMING SIMULATIONS OF ELECTRONIC SYSTEMS

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Abstract

When creating educational simulation models, and in classes where computer simulation experiments are used, what frequently happens is that some students meet the targets and achieve the intended educational objectives earlier than the teaching time planned for this activity expires. The teacher can resolve such a situation in an appropriate manner, by encouraging the creativity of the "fast" students. This article is concerned with the possibilities of increasing students´ activity in classes where computer simulation of electronic circuits is used. Using a particular example of a simulation experiment, it shows one possible option for how to engage students in the classwork. To achieve this, the function of "fault", available in the majority of electronic virtual computing labs, is used. This feature allows a teacher to assign one of three possible errors to a selected component; students have no direct way to find out which component is faulty. To resolve the problem, they must use their own creativity and effort, their own ideas, knowledge, and skills, and the tools that they have available in the electronic laboratory.

Keywords

simulation model, educational experiment, electronic circuit, creative activities

Introduction

Nowadays, there is no doubt that simulation should be part of the educational process. After all, a computer simulation provides a unique method of investigation (Hartmann, 1996), which makes it possible to verify the behaviour of models of unreal situations or situations difficult to perform (Michalík, 2014). The computer simulation model must be created in such a way that it can be executed on a computer. To achieve this, special programming environments are used; in the field of electronics, virtual electronics labs can be used. These laboratories comprise a great number of models of real discrete components that are used to build up a macro model of an entire circuit.

In its most general meaning, a simulation is understood as a process running on a computer (e.g., Hartmann, 1996). Therefore, the term “computer simulation” has become a set expression. In the field of research and development, simulation plays a significant role, as it makes it possible to verify a circuit design before building up a prototype of an electronic system. This method makes it possible to effectively verify the behaviour of a circuit under various conditions and situations which are very difficult or complex to perform in a prototype circuit. While some concepts rigidly distinguish between the terms “modelling” and “simulation” (e.g., Křivý, Kindler, 2003), at present “simulation” is often the only term used (e.g., Hubálovský, 2011), comprising the creation of a computer simulation model, including conceptual ones. In the educational process, a simulation has the potential to develop the creativity of students and can also be applied in project teaching (Kratochvílová, 2006), (Maňák, Švec, 2003).

The advantages and disadvantages of computer simulations are generally listed by Sokolowski and Banks (2009). From the point of view of the educational process, the main advantage is considered to be the fact that the simulation makes it possible to shorten or to accelerate the behaviour of processes and phenomena, that is, to influence the real time of the simulation, thus to contribute significantly to achieving educational objectives.

Simulations in Classes

Running classes in virtual electronics laboratories makes the teaching and learning process to a certain extent unique. What makes it specific is predominantly the fact that in classes, students work with models of electronic systems (models of the particular discrete components, partial or complete circuit arrangements) and the accuracy of simulation outputs depends to a certain extent on the quality of the models.

Another fact making the model-assisted teaching unique is the educational simulation model being structured to meet specific educational objectives. To illustrate, educational simulation models will look one way if the educational objective to be achieved is to comprehend and verify their working principle, and another way if the focus lies in specific properties. While in the first case, ideal models of components will be used in the circuit structure, in the other case, a model of a real component will be selected from the component library.

Modern simulation programs for electronics incorporate some functions which were not primarily created to be used in classes, but can facilitate the process of building the macro-model of a circuit, i.e. the process of its wiring, and also some functions which can be useful to increase students’ activity in classes (Michalík, Benajtr, 2014). For instance, the following functions can be used in classes: circuit wizards, the function of “Electrical Rules Check”, serving as a check of the assembled circuit, and the function of “Fault”, allowing the teacher to assign a fault to a particular component.

Active Learning

Maňák (2012) defines active learning as a method of instruction which emphasizes students’ direct involvement in the teaching process, their active thinking, their active engagement in classwork activities, the classwork activities themselves and finding solutions to problems.

Active learning lies in students' individual approach to learning. In this student-centred approach, the teacher adopts the role of a guide, guiding, controlling and helping students to achieve the desired target. The students' activity is understood as an intensive activity based on both the spontaneous interests of students and their conscious effort (Maňák, 1998).

The active learning methods successfully applied nowadays are the heuristic teaching methods (Maňák, 2012). They can be based on the principle of searching for the correct way using the method of trial and error. Active learning methods exploit the existing knowledge and skills of students and at the same time, increase and deepen them. Active learning may also involve project-based learning in groups (Rohlíková, Vejvodová, 2014), (Kratochvílová, 2006).

The objective of the active learning approach is to increase the students' existing level of knowledge and skills through students' work done on a voluntary basis, spontaneously and independently. These principles are also fully applicable in students' active approach when creating models in simulation programs and environments (Šimandl, Vaníček, 2015).

Educational simulations develop many key competencies of students, learning competence in particular, because students are able to apply their theoretical background knowledge to create educational simulation models. Students also develop competence in problem-solving. Communicative competence is not neglected either, as students are able to interpret the results of simulation experiments.

Case study: "Fault" Function promoting Active Learning

Most virtual electronics labs enable teachers to assign some particular faults to individual components. The teachers in fact simulate errors that may happen in components of an actual circuit. By setting the faults, teachers can indirectly test students' knowledge and skills more deeply. In addition, teachers can re-engage the "fast" groups of students that meet the targets and achieve the intended educational objectives earlier than the teaching time planned for the activity expires. Faults can be assigned either to individual components or they can be generated automatically over the entire circuit. All these settings are saved in the same file as the circuit itself. The function of "fault" can be used to set follow-up tasks and further encourage the creativity of fast finishers. These fast groups of students should not be "left to their fate"; it is desirable to focus the students' creative ideas in the right direction. The teacher adopts a role of an advisor, helping students to achieve the newly set educational objective, i.e. to discover why the electronic circuit does not work, which component is faulty and in what way.

In order to prevent students from going to the settings dialog window to find out about possible faults assigned to a component, it is possible to hide or lock some of the program settings and functions. It is desirable to hide the component faults by using the function of "Hide component faults". The task can be made more difficult by hiding component values, locking subcircuits, disabling the toolbar of instruments or disabling all possible changes to the circuit (i.e. the functions of Hide component values, Lock subcircuits, Disable instruments toolbar and Schematic read-only). All this can be used in classes in order to meet students' needs and to promote active learning even further.The simulation program Multisim NI allows the teacher to select a component and assign one of three possible faults to it. The component can be set

"Open", which means that the circuit is open due to a loose connection on the component terminal. Another type of fault that can be set is a "Short" or "Leakage", which is a fault related to partial conductance, which can be further specified by setting the amount of resistance between the individual terminals. All these simulated faults may occur in an actual circuit.

Fig. 1 shows a dialog window of the Multisim NI program at the instant of setting the fault. The selected component, an operational amplifier in this case, is being made faulty by setting a "short"-type fault between its inverting input terminal and its output terminal. The option of "None" is checked if there is no fault assigned to the particular component. In addition to the settings described above, the virtual electronics lab makes it possible to disable the individual types of circuit analysis, so that students cannot do them. In order to prevent cancelling or changing the limitations being set, the teacher can password-protect this dialog window. The password is saved to the same file as the simulation model.

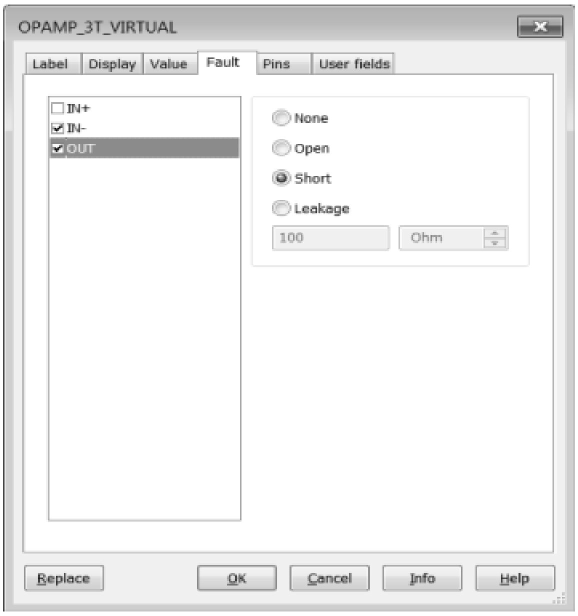

Fig. 1: Dialog window of the Multisim NI program at the instant of setting the fault

Fig. 2 depicts an example of a diagram of a push-pull amplifier with complementary transistors and a split voltage source. The output devices are represented by T2 and T3 transistors and are fed from the pre-amp represented by the T1 transistor. The simulation model was created in the Multisim NI program.

The "open" fault type is assigned to the T2 transistor of the output device. The input signal is generated by a function generator, which generates an alternating signal of a harmonic waveform. Its parameters can be found in Fig. 2.

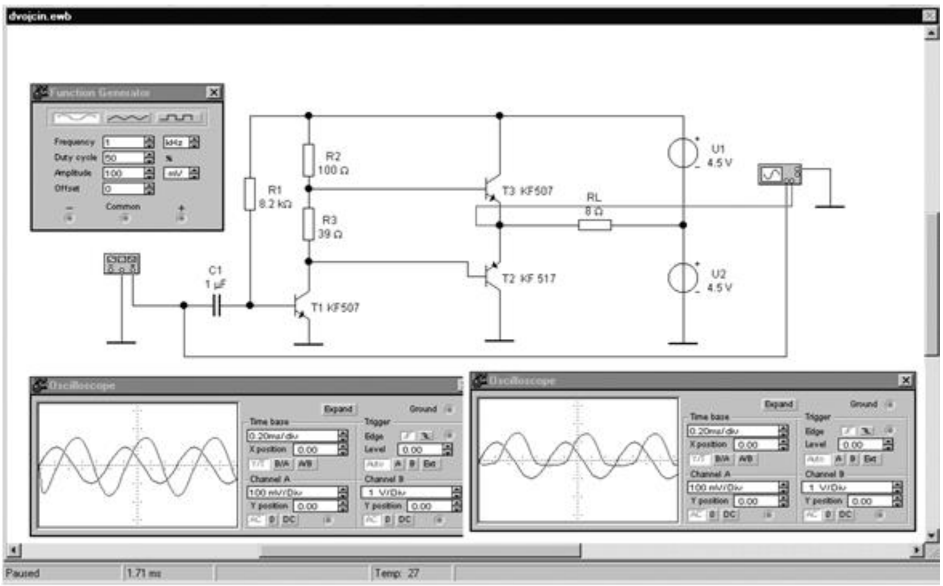

Fig. 2: Example of a diagram of a push-pull amplifier with complementary transistors and a split voltage source

The oscilloscope on the left displays the waveforms of the input and output signals before setting the fault. The oscilloscope on the right shows how the fault affected the output signal. In order to make the readings clearer, it is possible to distinguish both the waveforms in colour by colouring the conductors supplying the individual oscilloscope channels.

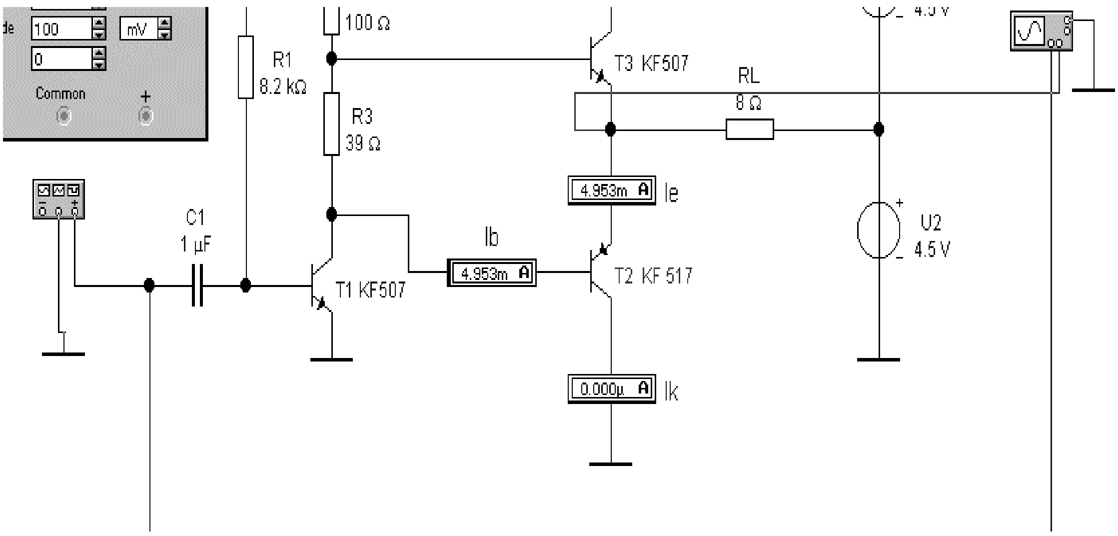

Fig. 3: Measure the currents passing through the electrodes of the “suspect” transistor

In this case, students are allowed to use all measuring instruments available in the virtual electronics lab. In order to find the fault, students should gradually measure currents passing through the individual transistor electrodes in the output device and verify if the transistor characteristic equations are valid. In this case, finding the fault will probably not be a problem because the output signal waveform displayed on the oscilloscope clearly indicates that the amplifier does not process the negative half-wave of the signal. Students might therefore consider the T2 transistor to be faulty. One method students can use to confirm their assumption is to measure the currents passing through the electrodes of the “suspect” transistor, as shown in Fig. 3. The T2 transistor exhibits zero collector current and its base current is the same as its emitter current. This confirms the assumption that the T2 transistor is faulty.

Another way to increase students’ activity when simulating the behavior of electronic systems is to fiddle with the models of the individual components. For instance, it is possible to modify the parameters of the existing components, thus creating a model of a new component. Or, a selected component can be set “faulty” by setting some of its parameters beyond the value limits listed in the component datasheet. Such a component then does not exhibit any of the three types of fault described above, but still its behavior does not correspond to the information in the component datasheet. This method can lead to active learning and encourage students’ creativity through searching for a non-standard component.

To illustrate, Fig. 4 shows the parameter modification of the current amplification factor of the BC338 transistor. One of the amplification factor interval limits, represented in the model by the hFEmin parameter or the hFEmax parameter, can be set far beyond its datasheet limits. For example, it is possible to set the hFEmin, i.e. the lower limit of the amplification factor, to 10. This value is ten times lower than the datasheet limit. This method makes it possible to create a new model of the component, exhibiting unique behavior. The greater the change in the parameter is, the more distinct the behavior of the circuit will be. The students’ task is to find the component with the modified parameter. This is a much more difficult problem than when using the “fault” function.

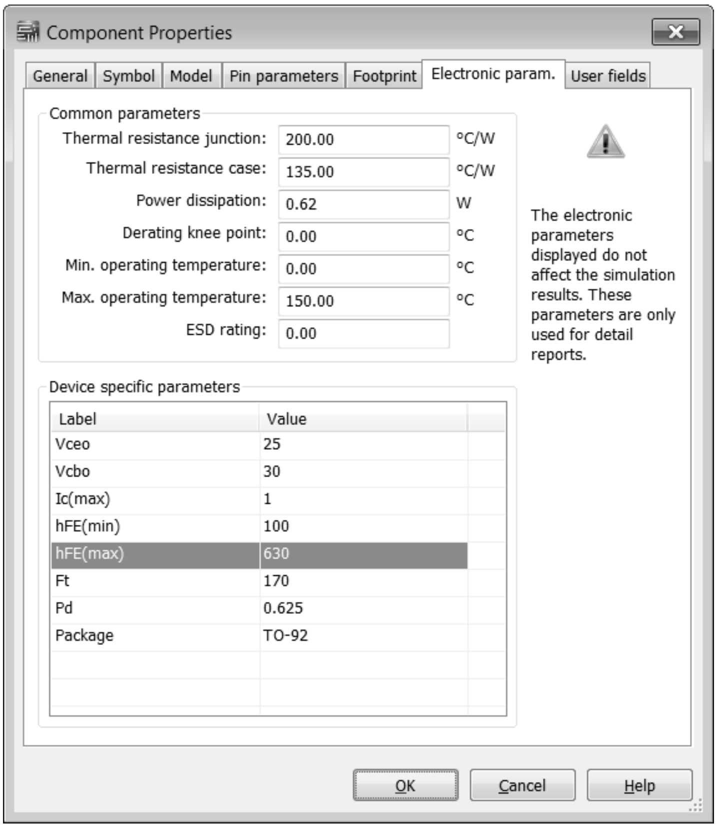

Fig. 4: Dialog window of the current amplification factor

Lesson Plan

Let us introduce here, as an example, a lesson plan including the lesson timing.

The key competencies that are developed through creating a simulation model followed by the simulation itself are primarily the following: learning competence, problem-solving competence, communicative competence and in some students, individual creative competence. What is needed is a computer work station with the simulation program installed. The particular objectives to be achieved can be described as follows: students can describe the structure of the particular simulation model and interpret the simulation results displayed, for example, as graphics output. Through a simulation experiment run with correct initial conditions, students understand the working principle of the model circuit. At the end of the class, students are assessed orally. The evaluation criterion is achievement of the intended educational objectives. The teaching approach used in the first part of the class is teacher-centered instruction, while when creating the model and performing its simulation, an individualized form of learning is used, predominantly represented by group work.

The main advantage of exploiting group work in classes is that a student is gaining knowledge through creative activities done by the entire group. Therefore, it is helpful to be familiar with group work methodology. When applying group work in classes, the whole group of students can be further subdivided into smaller groups of two or three students, for instance. Each of these subgroups can choose a speaker who controls the subgroup activity and acts as its representative. At the end of a teaching unit, the representatives of the individual subgroups report to the whole group on the solution to the set task. The division of the group into subgroups can be done randomly (thus, a heterogeneous subgroup will be formed), or according to students' interests (students will choose one of the offered topics that will fit their area of interest), or the groups formed will consist of students who are friends (these groups are denoted as amicable). Maňák (2003) finds the heterogeneous groups the most suitable. However, group work also has some disadvantages. It makes lesson planning more time-consuming and there is a need to divide the whole group into smaller groups.

The following chart shows a simplified example of a lesson plan including the lesson timing. The allocated teaching time comprises two teaching units, both 45 minutes long. The target group consists of secondary-school students in the field concerned with electronics, currently in their third year of study. The topics of the two teaching units are the creation of a medium-difficult simulation model, followed by the simulation itself, including the appropriate interpretation of the simulation outputs. The expected learning outcomes are the following: students understand both the structure of the model created and, based on the simulation, also the working principle of the circuit created.

Timing (min)	**Lesson Content**	**What Teacher Does**	**What Students Do**	**Teaching Methods/ Forms**
3	*Introduction*	*Informs students about the educational objectives*	*Ask questions regarding the objectives*	*Discussion/ teacher-centered instruction and individual work*
15	*Specific educational simulation model*	*Presents the background regarding the creation of the educational simulation model*	*Ask questions regarding the presentation*	*Presentation and discussion*
25	*Creation of the educational simulation model*	*Walks around the classroom and helps students to build the model*	*Work independently on the simulation model*	*Individualized form of teaching*
14	*Setting the initial conditions for the simulation and the simulation itself*	*Coordinates the students' work*	*Work independently in the environment of the simulation program*	*Individualized form of teaching*
13	*Interpretation of the simulation outputs*	*Checks the results of the simulation for errors, encourages students to achieve the educational objectives*	*Interpret the simulation results, if need be, the graphics outputs, etc.*	*Individualized form of teaching*
15	*Re-engaging fast finishers; finishing the model and the simulation by the other students*	*Re-engages some students by using the Fault function, for example*	*Some search for the faulty component; others finish the model and interpret the simulation outputs*	*Individualized form of teaching*
5	*Summary of the unit*	*Evaluates the class; uses the simulation outputs to highlight the educational objectives achieved*	*Listen to the teacher; if need be, answer teacher's questions*	*Teacher-centered instruction*

Conclusion

The aim of this article is to demonstrate ways of engaging students in classes where simulations in a virtual educational electronics lab are used. The need for re-engaging fast finishers occurs when some students meet the targets and achieve the intended educational objectives earlier than the teaching time planned for this activity expires. An illustrative example is used to demonstrate the application of the "fault" function, which is available in most virtual electronics labs, for re-engaging fast finishers. When working with the simulation program, students are not limited by the number of components or measuring instruments, such as ammeters and voltmeters. However, there might be some limitations in the number of such types of component that comprise ready-made simulation models. Although there are tens of thousands of component models, sometimes the required type is missing. Nonetheless, a model of an equivalent component might be available. It is also possible to modify the parameters of the existing model, thus coming close to the model of the desired component.

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INFORMATICS EDUCATION: CURRENT STATE AND PERSPECTIVES OF DEVELOPMENT WITHIN THE SYSTEM OF FIELD DIDACTICS IN THE CZECH REPUBLIC

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Abstract

This study offers an overview of the current state in the field of informatics education in the Czech Republic. The new publication of a monograph focusing on field didactics showed that a complex analysis of the current state and future perspectives of developments in informatics education that has not yet been addressed is needed. This paper presents an overview of development in the discipline from the 1960s, defines the main goals of informatics education in the Czech Republic, namely the contents and methods of ICT and computer science education, the need to revise the content areas in official pedagogical documents, teacher education including training of primary teachers and methodology of research in the field of informatics education. The authors of the paper analyse current trends that have impact on informatics education and also refer to the dynamics of computer science education, gradual shift of computer science to lower school levels and introduction of new computer science topics into the area of information and communication technologies. In the conclusion the authors formulate the current problems that informatics education will have to tackle and indicate the possible dangers and perspectives of its future developments. In this article, we distinguish between informatics education as a school subject education and computer science education and ICT education which we understand as parts of this school subject in this context.

Keywords

informatics education, field didactics, computer science education, ICT education, school subject, curriculum, subject matter, computing

Monograph on field didactics

Currently the Czech Republic witnesses growth of field didactics. Until 1989 field didactics were underpinned by communist ideologies and were rooted in the context of building the communist society. They copied Soviet pedagogy and didactical approaches used in former Soviet Union. The changes in 1989 brought new impulses and revival. One of the milestones of this revival was the establishment of the permanent working group for field didactics of the Accreditation Commission of the Czech Republic. The core of the team of authors of the comprehensive monograph, which gives a detailed account of most Czech field didactics, is made of members of this working group. The new monograph comes out of the newest resources including foreign work, it builds on reviews and discussions in various communities of field didactics but also on more widely conceived discussions within the group of Accreditation Commission.

The main authors Iva Stuchlíková and Tomáš Janík (2015) present 11 different field didactics in the monograph. Each field didactics is presented in a separate chapter where the authors give an account of its historical development and current state, achievements, define the current problems and perspectives. Despite that fact that the monograph does not give an account of all field didactics it presents informatics education, which is very good news for the discipline as the monograph clearly supports emancipation of field didactics in the conditions of the Czech Republic. The authors of this paper were asked to prepare the chapter about computer science education for this monograph, which was an incentive for them to look into the issue of computer education and education with computers in the context of other field didactics.

The monograph opens with an introductory chapter in which the main authors give the reasons for establishment of field didactics, where they define the concept of field didactics as the amalgam of subject and pedagogical component of the discipline and explain the status of field didactics in the light of the concept of pedagogical content knowledge [Shulman]. The concluding chapter offers an overview of balancing and perspectives as perceived by the authors of the individual chapters and outlines the prospects of future developments in field didactics.

The aim of the chapter on computer science education is to introduce the discipline as a newly evolving discipline in our country whose ambition is to break free from the wide initial conception of "using computers at schools" to a fully-fledged field didactics. The chapter gives a brief account of the history of introducing technologies into schools on international and national scope, it describes the current state of teaching computer science at schools, it presents the impulses for establishment of this discipline and also the current problems, dangers and perspectives of future developments of the discipline. The chapter also defines informatics education terminologically.

Foundation of informatics education as a discipline in Czechoslovakia and the Czech Republic

History of informatics education on national level can be studied both in the perspective of development of this scientific discipline (informatics didactics) and in perspective of development in the use of computers in school education. The terms informatics, computer science and computers are often blend in reality of Czech schools. A non-expert is likely to perceive informatics at schools as work on computers; and this actually was true when computers were first introduced to schools in the 1980s. As time passed this "arbitrary work on computers during lessons" was structured in a way that a general frame became a nest of fields of stand-alone areas of computer assisted instruction, educational technology, information and communication technology education and computer science education as the didactics of the discipline.

Computer assisted instruction (CAI) deals with teaching particular subjects using technologies, i.e. is closest the field didactics of the different subjects. Educational technology studies transformation of education in consequence to integration of technologies into teaching and learning processes. The discipline, sometimes referred to as e-pedagogy, focuses in more general pedagogical or didactical issues. In the context of Czech schools it is useful to distinguish two streams in informatics education with respect to the relation of a learner to technologies. **Information and communication technology education** (ICTE) focuses on competences in using and operating digital technologies on users' level. **Computer science education** (CSE) is a didactics of the fundaments of the scientific discipline computer science and puts emphasis on creative and authorial approaches to technologies.

There is one major difference between informatics education and other field didactics: it came into existence more or less simultaneously with establishment of its mother discipline. This means that didactics was accompanying computer science already at the time when its subject and methodologies were only evolving because the demands of society were that the evolving discipline should also be handled didactically. Naturally this meant that informatics education was from its very beginnings influenced by significant formative changes in the unstabilized mother discipline.

History of school informatics is relatively short in our country. At the beginning all the above mentioned disciplines blended into generally understood teaching with computers and of computers. The 1970s were the decade when computer science was introduced at technical universities. Pioneer works in the area of computer assisted education started to be published in 1960s and later, e.g. the work about programmed learning (Tollingerová et al., 1966), Kulič's publication (1984) Člověk – učení – automat (Human – learning – automat) in which the author looks into psycho-didactical aspects of computer science for the first time, and the works of E. Mazák (e.g. Kraemer, Mazák, 1986, Mazák, 1991).

Fans of computer technology started to meet in the division n. 602 of the organization Svazarm (Union for cooperation with the army) in the first half of the 1980s. This became an informal centre of leisure or afterschool activities in computer science. The division provided courses of programming for public. It was the place were methodological and teaching materials about programming were created, e.g. for the series Mluvíte počítačsky? (Let's talk computers), which was published in the magazine VTM (Pecinovský, 2009).

In the second half of the 1980s the government introduced a programme of computerization of schools and started to equip schools with eight-bit microcomputers produced in Czechoslovakia. These were used on upper secondary schools mostly in optional subjects, on primary and lower secondary schools in afterschool computer clubs. Most of the teaching focused on programming. The teachers used not only the professional programming languages such as Basic and Pascal but also the so called children programming environments such as Robot Karel or Žofka, Czechoslovak version of the language Logo (Vosátka & Černochová, 2001). Also the first competitions in programming for children were organized. The subject *Informatics and computer technology* was introduced on upper secondary grammar school in 1990 (Vosátka, 1991). Students were allowed to take the subject at school leaving exam (maturita). The first upper secondary school textbooks of programming were published (Kroha, Mannová & Štulc, 1990).

In the 1990s when computers became easily available, the teaching gradually transformed into teaching users' skills, at first work with office applications, in the end of 1990s use of the internet and electronic communication, i.e. the areas that are nowadays understood as digital literacy. The curricula were reduced to use of applications and devices (Blaho, 2012).

The situation in elementary schools in the 1990s was that topics from computer science (non-compulsory) were taught in three different subjects: *Informatics* (using a computer), a theme *Work with computer* in the subject *Technology* (using applications, technical issues) and *Mathematics* (algorithmization using flowcharts taught without computers). There were a few exceptions outside mainstream ICT education in some schools where the basics of algorithmization was taught in the environments Baltík and Comenius Logo. Programming was taught at schools only rarely.

A project important for introduction of computers to secondary schools was the Comenius project established on the basis of intergovernmental agreement between the Netherlands and Czechoslovakia (Svoboda, 1992). Within this Comenius project, a number of original Czech educational software products were developed, e.g. remote laboratories ISES (Lustig, 1997) or simulation software for teaching physics Famulus, (Dvořák, 1992).

In the first half of the 1990s, methodological support to teachers was provided by the Institute for Information on Education (ÚIV), which served as an in-service training and methodological centre; it developed methodological approaches to teaching programming, e.g. (Berezovský, 1993), guides for work with technologies. Since 1991 the Institute was publishing the Bulletin of Informatics and Computer Technology for Secondary Schools and later the Bulletin of Information Technologies at Schools with the aim of mediating information on computing worldwide and computer-aided learning abroad to the teaching public and with the aim of publishing reviews of books that were milestones in the development of the use of computers in learning, e.g. the work of Papert (Miller, 1993).

At this stage we cannot speak of informatics education as a field of study. The pressure from schools stemming from gradual introduction of topics focusing on work with computers into school curricula resulted in creation of methodological materials and textbooks, e.g. *Práce s počítačem* (Work with computer) (Rambousek et al., 1997), of the first scientific publications on the potential of the use of computers in teaching (e.g. Černochová et al., 1998). In the 1990s and in the first years of the 21st century, the main expert centre of informatization of Czech schools was the national conference *Poškole* about computers at school (fifteen conferences were held in the years 1992–2007), where pioneers of introduction of computers to schools from all types of schools could meet the representatives of the Ministry of Education, school inspection, non-governmental organizations and companies and where they followed and shared innovations and examples of good practice in different subjects in the area of the yet unclassified field of the use of computers at schools.

Methodological support of schools from universities, especially from departments of computer science or computing focused especially on (talented) secondary school students. High quality textbooks of programming were published, e.g. (Töpfer, 1995, Pecinovský, Virius, 1997) as well as articles focusing on problems for Mathematical Olympiad in Programming.

In 2000 the government of the Czech Republic approved the Conception of Government Information Policy in Education (abbreviation SIPVZ), within the frame of which all schools were equipped with computers and teachers trained in basic digital literacy skills. A part of this training was also in-service training for teachers of different subjects in the use of computers in teaching their disciplines. The success of this type of training was negatively affected by factual non-existence of research in the field and by a lack of teacher educators in this area. This situation clearly showed the practical need of addressing the issue of computer-assisted instruction in different field didactics.

The new Act of Education 2006 brought compulsory ICT education into all schools, both on primary and secondary school levels. However, the educational area Information and Communication Technology was given minimum time allocation of just one lesson a week in one grade of primary, and one grade of lower secondary school. With this allocation it is impossible to achieve the expected outcomes in the area as they are defined in the Framework Education Programme for Elementary Education, which Neumajer points out in the report from the Panel for Innovation of National ITC Curricula at the Educational Research Institute in Prague (Neumajer, 2009).

State curricular documents focus exclusively on the area of digital literacy and basically disregard all computer science topics both at primary, lower secondary and to a great extent also upper secondary school levels. Computer science topics have taken on the form of factographical discipline or are included in specialised subjects and study disciplines. The outcome is that graduates from upper secondary schools applying to study computer science at universities not only have not mastered the basics of the disciplines, moreover, in contrast to mathematics or natural sciences they have no idea what computer science actually is, what it studies**.** Their idea of computing is the idea of application control and use of computers (i.e. consumption of technologies).

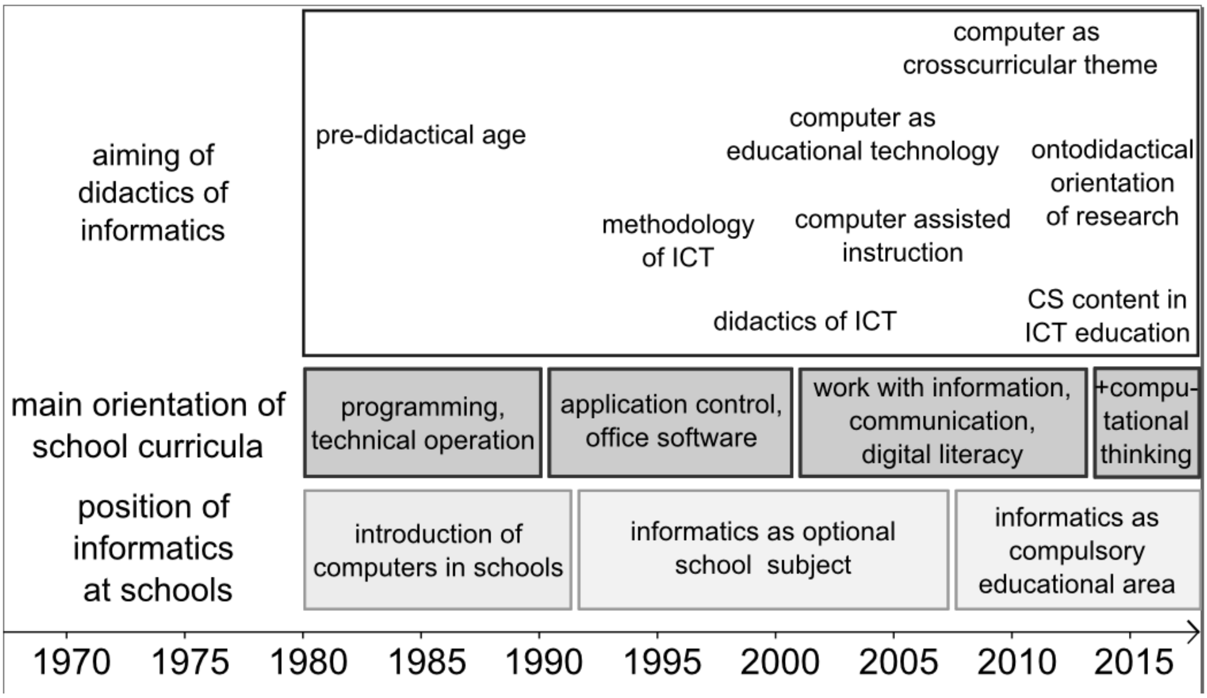

Fig. 1: Historical outline of the stages of development of teaching informatics and the focus of field didactics in Czechoslovakia, later in the Czech Republic

Incentives to develop of informatics education in the Czech Republic

This part describes current problems of school education (e.g. curriculum, international comparative studies, testing) and based on this information draws attention to the need of field didactics expertise. We could expect arguments saying that teaching topics from computer science is not compulsory at schools, that the subject ICT has minimum time allocation and that pupils only learn to use ICT in the subject, teachers are not able to teach topics from computer science and anyway, there are no prospects for improvement of the situation in the area, so why should computer science education be established as a scientific discipline in the Czech Republic. Let us focus on the reasons that speak for foundation of this discipline.

Focus of the educational area "ICT and informatics"

What is the position of informatics at Czech schools? The educational area *Information and Communication Technology* is compulsory on all school levels in the Czech Republic, which is positive. However, the position of the subject is abated by

- insufficient time allocation (e.g. it is 11x less than time allocation of history and civics on lower secondary school level),
- isolation (pupils use computers very rarely in other subjects, which is reported e.g. in the Annual Report of the Czech School Inspection for 2010/2011 (ČŠI, 2011, p. 46),
- quality of teacher training (teaching qualification of only 18 % of the respondents in a research survey among ICT teachers at lower secondary schools is oriented on the area of informatics or some closely related discipline, see Rambousek et al. (2013, s. 13),

- last but not least by the content taught although this is not perceived as a problem by in-service teachers, which is shown in research of Rambousek et al. (2013, p. 188–203).

Mainstream ICT education in Czech schools currently focuses on application control and office software and significantly plays down computer science. User approaches to ICT in the curricula defined in the *Framework Education Programme for Elementary Education* are reinforced in the chapter Use of digital technology, which belongs to the area of Humans and the World of Work. In other words Czech schools nowadays produce (with respect to computer technology) predominantly users, consumers. This can be easily documented in current framework education programmes (RVP ZV, 2013, RVP G, 2007).

Content and methods in teaching informatics

Digital technologies are reality and nobody doubts they will be used at schools. But do we know how a child learns to work with a computer, how it develops its ideas and concepts of how information systems work, what topics and issues from computer science a child is able to solve at different stages of its development and age levels, how it acquires concepts, language means and procedures used in computer science?

As Dagdilelis et al. (in Hadjerrouit, 2009, p. 229) point out, informatics is still taught "as if this subject is just a tool. As a result, informatics teaching does not provide understanding on a deeper conceptual level than memorizing details of the software, reproducing information about buttons, menu commands, and dialogue boxes". Most upper secondary school students learn informatics "by approximations and imitations, reproduction of information, and not by conceptual understanding" (Hadjerrouit, 2009, p. 229). "students know a lot about information technologies, but they do not possess a conceptual framework to organize them", Hadjerrouit (2009, p. 229) claims building on the works (Haberman, 2004; Nishida et al., 2009).

Even if we replace topics of application control and use of computers by topics from computer science, teaching might still be of instructional nature similarly to the way it is conceived now, either due to rigidity in approaches to teaching or due to insufficient teacher education. Blaho (2012, p. 8) describes the situation in Slovakia where computer science is often taught frontally with the aim of transmitting many facts, concepts and definitions without relating them to children's experience, disregarding the age and level of children. Moreover, these fact may be easily found on the internet.

Need of revision of the educational area in Framework Education Programmes

"School informatics builds its objectives on ICT skills but these skills are not the objectives of computer science" (Blaho, 2012, p. 11). This sentence seems to have captured the basic problem of Czech school informatics and its didactics. Our experience confirms that many upper secondary school teachers do not make a difference between teaching computer science and teaching ICT and when teaching computer science they focus on teaching application and technology control. And it is also the authors of textbooks and curricular documents who are responsible for the focus of ICT area on work with office applications. Teachers, who very often lack training in teaching informatics and are "self-made", find it difficult to "decipher" framework education programmes that are too vague and incomprehensible for their needs (Rambousek et al., 2013).

Another incentive for systematic building of informatics education was preparatory works on state maturita (high-school-leaving exam) in ICT and Computer Science as one of the compulsory elective subjects. These works showed that the contents and structure of the educational area ICT as described in the Framework Education Programme for Secondary General Education (2007) are not sufficient for preparation of the exam of this importance. Moreover, test items prepared by in-service teachers were very often fact-based, memory-based and very rarely problem-based.

The demand to include ICT and Computer Science into the common part of state maturita is an expression of the importance of ICT competences in the profile of an upper secondary school graduate. However, the question is whether Czech schools were ready for the challenge. The decision not to prepare state maturita exam in this educational area in fact prevented a very dangerous situation. Taking into account how unanchored, fluid and unspecific the contents of this educational area are, the maturita exam would have only reinforced the conception of the subject as teaching application control, which would become the main trend in ICT education for years.

Need of qualified teachers of informatics on all levels of schools in the Czech Republic

A major shortcoming of education in the area of ICT is that it is often taught by teachers whose undergraduate studies did not focus on teaching computer science or related disciplines. Research of Rambousek et al. (2013, p. 13) shows that the teaching qualification of only 18 % of respondents (informatics teachers at lower secondary schools) is oriented on informatics or some related discipline (which does not mean they actually studied computer science). ICT competence of most teachers is on the level of advanced users of ICT. Only 40 % of informatics teachers evaluated their competences as better than is actually needed for teaching the subject well. The same research also shows a number of negative pupils’ comments doubting the expertise of their informatics teachers (p. 13).

A teacher whose education in the discipline is not sufficient might have very distorted views of the discipline as such. In a survey of preferences of thematic units of informatics curriculum, preservice teachers of ICT see application control, work with the internet and teaching of software and hardware as the most important topics; themes from computer science are on the periphery of their interest (Vaníček, 2010, p. 199). The same survey showed that teachers prefer pupils’ **activity of user or consumer nature** to creative activities (e.g. editing digital videos). They also tend to prefer the areas in which they perceive themselves as experts (p. 200).

Unqualified teachers tend to pay attention to topics in which they excel, which is very often control of basic applications for editing texts and browsing on the internet. Czech teachers of ICT disciplines find it important to teach what they can do really well (Rambousek et al., 2013, p. 10). The topics Czech primary and lower secondary informatics teachers find least important are databases and algorithmization, i.e. topics from computer science (Rambousek et al., 2007; Rambousek et al., 2013, p. 11).

Another important issue is how to educate future teachers in the area. According to Hadjerrouit (2009, p. 229) "teaching methods based on traditional epistemologies are still dominant despite the fact that informatics as a school subject requires a new pedagogy that goes largely beyond the use of IT as a tool". "Teachers need a new vision of informatics that goes beyond the use of IT as a tool. A new approach to informatics should rely on learning theories, conceptualizations, and pedagogical principles rather than imitation, approximation, memorizing, and interaction with the computer." (Hadjerrouit, 2009, p. 230)

Focus and methodology of research in computer science education

The focus of research in the Czech Republic is connected to the position of informatics in Czech primary and secondary education. No attention was paid to this field didactics in the 1990s. The whole area was perceived as using computers in the classroom. Zounek (2004) claims that there was an absence of papers dealing with current issues of teaching computer or informatics oriented topics in journals for the teaching public. A change comes with the turn of the century and the beginnings of e-learning and online education (Lustigová & Zelenda, 1999).

Research in the last decade has focused predominantly on ICT and its use at schools. E.g. Zounek et al. focused on questions of where exactly technologies are used at schools (teaching, management) and what obstacles block its larger expansion (Zounek, 2006; Šeďová & Zounek, 2007). Neumajer focused on school webs (2005), Mašek and his colleagues on new open technologies in education (Mašek, Michalík & Vrbík, 2004). Rambousek et al. (2007) conducted research in the area of development of ICT competences of pupils in the area of teaching activities, thematic units, studied the state and structure of primary and lower secondary pupils' and teachers' competences. No distinction was made between the terms ICT and computer science as there are references e.g. to computer science teaching activities of cross-curricular nature (p. 9).

Another sphere of interest is the field of e-safety while working with technologies, i.e. issues of interpersonal relationships, communication, cyberbullying etc. These topics are studied e.g. by (Kopecký et al., 2013; Szotkowski et al., 2013). Another area of interest is personalization of e-learning and its adaptive mechanisms (Šarmanová et al., 2009, Kostolányová, 2012). Significant attention is paid to investigation of digital literacy of adult population.

The change in the focus of research towards computer science is relatively recent. This research focuses on how preservice primary school teachers perceive topics from computer sciences included into the ICT area, namely basics of algorithmization and work with information (Vaníček, 2013). There are pilot projects for teaching algorithmization on primary school level based on cross-curricular cooperation, e.g. with art or languages (Černochová & Komrska, 2013).

Computer science education currently faces the problem of lack of empirical research, especially lack of didactic experiments. With respect to methodology, the existing research is predominantly exploratory – probes. There is a shortage of research focusing on situation in the terrain, at schools, based on lesson observations and reflection. However, taking into account the unanchored nature of the topics of the school subject this may not necessarily be a drawback.

Czech research focusing on education in subjects related to informatics and computer science on primary and secondary schools is very scattered, lacks coordination and is very haphazard.

An example of involvement in international cooperation is the cooperation of more than 30 countries in the Bebras Challenge (in Czech Bobřík informatiky, Beaver of Informatics), which focuses on algorithmization, comprehension of information and its representation, coding, understanding structures, problem solving, social contexts of ICT and everyday use of computers. It takes in account that "understanding and handling the basics and foundations of computer science is more important than knowing a lot of details" (Dagienė, 2008, p. 217). Within this cooperation research focuses on computational problems as the basic components of curriculum, the criteria of their quality and their taxonomy (Vaníček, 2014).

Overview of journals published in the Czech Republic with focus on informatics education

- *Journal of Technology and Information Education* (JTIE): the journal focuses on publication of results of research surveys, theoretical studies and papers dealing with technical education, teaching computer science and computer science education. The journal is published in Czech with abstracts and some articles in English. URL: jtie.upol.cz
- *International Journal of Information and Communication Technologies in Education* (ICTE): The mission of ICTE Journal is to mediate new findings and approaches of experts in the field of ICT application in education. The main topics of interest are integration of ICT in education, didactic principles of ICT supported instruction, eLearning, computer based instruction and examination with the use of ICT. The journal is published in English. URL: https://periodicals.osu.eu/ictejournal
- *Matematika – fyzika – informatika* (MFI) [Mathematics – physics – computer science]: journal of a didactic nature focusing on issues of teaching at primary and secondary school levels and innovation in education. The journal is published in Czech. URL: www.mfi.upol.cz/index.php/mfi/index

Current trends with impact on computer informatics education

Currently informatics education is affected by the following:

- Dynamics of development in the field of ICT and computing,
- Shift of teaching informatics to lower school levels, even to preschool education,
- Introduction of computational topics into the educational area ICT.

Dynamics of the discipline

Dynamics of the discipline is a substantial obstacle that impedes transformation of informatics education from the stage focusing on selection of relevant topics, its didactic transformation and methodological support to teachers in the teaching process to the stage of proper basic research and development of methods unique for the discipline that would enable to establish informatics education as a true science. Use of digital technologies in contemporary society accelerates, which is reflected in emergence of new issues, e.g. internet safety, cloud solutions, mobile technologies. This is closely connected to privacy and the so called e-safety in online communication and in data sharing on the internet (Kopecký et al., 2013), to issues of relativization and virtualization of relationships.

The fact that dynamics of computer science surpasses dynamics of other disciplines makes it difficult to handle it didactically. According to Schubert and Schwill (2011), the content of the subject at schools should be directed towards the foundations of the discipline, towards building a conception of basic principles, ways of thinking and methods of computer science.

The need to react to the never-ending technological innovation and new applications is exhausting for teachers and does not result in any progress in their teaching. This atmosphere is reinforced by the myth that pupils can use computers better than their teachers. Social demands put pressure on educational institutions to react to these changes and in these turbulent changes it is very difficult to pinpoint the anchoring fundamental concepts, long-term competences overcoming this dynamics, to differentiate between topicality and fashion, to tell what important is etc. Informatics education is not able to break free from its utilitarian conception, from creating tutorials and manuals for basic control without any ambition to guide the learner to deeper understanding of the discipline.

Shift towards younger pupils

Availability of technological devices and facility of their use have made it possible to start teaching informatics at primary, and even preschool levels. Of course this must be reflected in preschool and primary school teacher education. It is only since 2012 we have been able to say that any pupil leaving lower secondary school in the Czech Republic has had a compulsory subject within which they were taught the basics of work with computers. This change has brought many difficulties, the most significant of which is inadequate teacher training in this area.

What informatics education in Czech primary schools is like can be documented by the following findings. A 2013 survey at schools participating in the Beaver informatics contest showed that 59 % of teachers of informatics at primary school level are lower secondary school teachers and only 40 % primary school teachers. This is potentially dangerous as a lower secondary school teacher may be transferring curriculum intended for older pupils to primary school level. Research in exclusively primary schools (the so called incomplete schools – a complete "elementary" school in this country has both primary and lower secondary school levels) shows that not every primary school in the country includes the compulsory subject ICT in its school education programme and sometimes is taught only as a cross-curricular subject (i.e. within the frame of other subjects). E.g. there are 48 % of such primary schools in the Ústecký Region where ICT is not taught as a stand-alone subject and 32 % in the Zlín Region (Pyszko, 2013).

This trend brings questions of how pre-primary education should respond to this situation. A UNESCO study that maps situation in pre-primary education (Kalaš, 2010) draws attention to the potential of technology for children's creative work and collaboration. Undoubtedly there are many dangers involved as well, e.g. overuse of technology. According to Siraj-Blatchford (2006) the concept of developmental adequacy is of key importance in this respect. Preschool teachers need support to be able to assess critically age appropriateness of digital technologies, to understand their role and the potential of their integration into kindergarten environment (Kalaš, 2010).

Introduction of computational topics into school education

We can observe some other recent changes related to digital technology in the world that have impact on school curriculum. It is the trend of including computer science topics into teaching work with computers, i.e. the trend to teach more than digital literacy. Already in 2003 Allen Tucker from Association for Computing Machinery (ACM) declared in the Report of ACM K–12 Task Force Curriculum Committee that one of the objectives of computer science K-12 curricula must be "introducing the fundamental concepts of computer science to all students, beginning at the elementary school level" (Tucker, 2003, p. 10).

All these recent efforts are based on the need to **develop computational thinking**; this concept was defined by J.Wing (2006) and is very closely connected to other universal fundamental concepts that go beyond contemporary technology: algorithm, structures, representations of information, information systems, coding, principles of operation of ICT. The shift from the concept of digital literacy to computational thinking can be perceived not only as broadening of the educational area but also as a parallel of transformation of transmissive teaching methods to approaches developing pupils' critical thinking and ability to solve problems, i.e. a trend that can be observed in other field didactics.

One of the basic concepts of computer science is the idea of algorithmization, language and structure decomposition (Schubert & Schwill, 2011, s. 89). However, we do not come across these concepts when informatics is taught as technology use and control. Thus ICT education is an inadequate background to later teaching of computer science.

Currently a number of countries are undergoing curricular reforms in which the position of computer science is redefined and changes, e.g. in Poland (Sysło & Kwiatkowska, 2013), in Slovakia (Blaho & Salanci, 2011), in England (CAS, 2013), in the USA (Seehorn, 2011) and other. We hope these trends will be taken into account also in the Czech Republic, since the government approved the document *Strategy for Digital Education until 2020* that will affect future modifications of Framework Education Programmes. This strategic material speaks of development of pupils' computational thinking as one of the three priorities (MŠMT, 2014, p. 14). This trend could be supported by the fact that the Czech Republic came 1st among all the studied countries in the international survey of information and digital literacy ICILS 2013 (Basl et al, 2014), which could result in the fact that focus of teaching on the area of digital literacy will not be perceived as most important part of the strategy.

Current issues in informatics education

Informatics education (informatics didactics) as a pedagogical discipline bears the signs of an emerging field that must respond to sociocultural factors, that must on definition of its educational content in relation to the relevant disciplines and interdisciplinary links, that must define research areas connected to the results of research of how people learn, communicate and think. There are many problems informatics education will have face. Let us list several of them:

- **Narrow base of informatics educators**. There are very few university departments with focus on computer science and ICT education in the Czech Republic. The departments that do focus on the discipline very often developed from departments specialized in technology education that later turned their attention to information education and digital literacy. Their research papers on Czech conferences were very often included in the sections Technical and information education (see e.g. Janík et al., 2004). These very few university departments employ one or two computer science educators, who very often have to teach also other subjects. In consequence their focus on informatics education is not clear-cut and the time demands of other duties do not allow them to be in everyday close contact with schools. There is no institution in the Czech Republic, whose only specialization would be informatics education.
- **Low involvement of university departments specialised in informatics and computer science**. Computer science education unfortunately attracts little attention of departments training informatics teachers. Usually there will be only one member of the department focusing on computer science education, the key research and training activities will be focusing on computer science, not on computer science education which is perceived as a “soft” science without strictly defined outlines. Informatics educators are then isolated or involved in research of non-didactical nature.
- **Non-existence of a habilitation institution or postgraduate** oriented on computer science education (unlike neighbouring countries like Germany, Slovakia). Dissertations focusing on computer science education or ICT education can only be written in the study fields Information and communication technology in Education, Applied Informatics and Pedagogy. The non-existence of the didactical field of the study means that university lecturers of computer science education have to study the discipline itself or didactics of a related discipline. This is probably the reason why there in no major research conducted in the field.
- **Nascent platform for cooperation** and exchange of knowledge and information. A conference in this field didactics and a place where teachers could meet and share their expertise did not exist for many years. From the 1990s its place was taken by the conference *Poškole* whose scope was much wider – it focused on any use of computers at schools and was not a purely scientific event. At the field of in-service teachers preparation, it was then replaced by the conference *Computer at school* (2003), which however also focuses on the use of computers in all school subjects. The traditional conference *Information and Communication Technologies in Education* (ICTE)

in Rožnov pod Radhoštěm exceeds the scope of informatics education. The future will show whether the conference DidactIG which has so far been organized three times will be able to take on the role of platform answering the needs of Czech community of informatics educators. Up to now this role was played by the Slovak international conference *DidInfo* with its more than twenty year tradition and focus exclusively on informatics education.

- **Teacher education of primary and secondary pre-service teachers of informatics and professional development and in-service support to informatics teachers** are equally as fragmented and scattered as its educators: on national level there is no system of in-service teacher training or a conference for teachers focusing on ICT and computer science, there is nobody to guarantee quality. One of the reasons for this lack of cooperation among informatics teachers might be that most of them are self-learners, they do not know where to seek help, support and advice. There is lack of really good textbooks of ICT and computer science, most teachers have to develop their own teaching materials.

Dangers and perspectives

Informatics education as field didactics in the Czech Republic is a newly established discipline. The prospects of its future developments can be summarized in a few points. The discipline will have to undergo the process of emancipation into a fully-fledge field didactics. It means its subject and methodology will have to be developed and precised in a narrow cooperation between Czech and foreign experts in the fields of informatics and computer science. We believe that developments in informatics education will have effect on the focus of government information policy and strategy of education.

Computer science education will have to face the pressure of the current situation and upcoming turbulent changes in schools, educational institutions, policy and teacher education (introduction of informatics education to primary and preschool teacher training). The need of permanent answering to the changing situation will always affect the space and time for base research and specialization of the field, which will always be limited, and methodological applications of applied research in school practice will be expected.

One of the risks for the disciplines is that school informatics will still focus on teaching user approaches to digital technologies, which will always put pressure on directing attention of computer science education to these ends. In the light of observed trends, this directing must be perceived as a route without perspectives. We hope that international cooperation with the aim of including computer science topics into ICT education at schools and the related research will bring fruit.

Emancipation of informatics education will definitely be supported if pedagogy takes over responsibility for the area of use of information technology in education (including e-learning) and other field didactics will address computer assisted instruction in their subjects. If computer is becoming an everyday object in our society, research in various fields of pedagogy should incorporate computers as an everyday classroom tool and not to set aside and isolate technologies at schools, teacher education and education science as such.

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DIDACTICS OF PROGRAMMING

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Abstract

Programming is as an important part of informatics at Slovak schools, and therefore we put focus on didactics of programming. We have observed various issues that are related to teaching and didactics of programming. These issues should be mastered by future teachers of informatics that we prepare at our faculty. In order to prepare future teachers we have designed a course of didactics of programming. For example, we have observed that our students – future teachers do not differentiate between levels of complexity when trying to teach various programming topics, or they skip important steps when explaining solution of a problem. We came to conclusion that it is necessary to design various activities related to teaching of programming and problem solving that allow students to collect their own practical experiences by resolving various didactical problems and to develop their critical thinking about teaching.

Keywords

programming and problem solving, didactics of programming, future teachers of informatics, didactical problems

Introduction

Informatics education has various regional specifics in different countries. Therefore, we briefly explain the role of programming at primary and secondary schools in Slovakia. Then we take a closer look at didactic of programming which we consider as an important part in education of students – future teachers of informatics.

The role of programming in Slovak schools

Programming has been for decades a very important part of school informatics. In the 70s there were only a few high schools that had classes with a focus on programming (e.g. Gymnázium Jura Hronca in Bratislava). Informatics has become a compulsory subject at high schools in the 80s. During this period, the teaching of informatics was reduced to teaching of programming

(programming = the second literacy). By contrast, in the 90s with the arrival of personal computers, internet and applications there was trend to teach controlling computer, select applications or type-writing.

Currently, we pay attention to programming again. It's because programming allows us to teach pupils to solve problems: to explore a given task, to choose a suitable representation of handled information, to invent and to write a solution of the problem, to evaluate and to correct its own or other’s solutions. The problem solving is currently considered as one of the most important competence. Then, such understanding of programming gives us a different sight on what is the goal of school programming.

This also means that we do not plan to train professional programmers, developers – perhaps the 99% of pupils will not be programmers. Our goal is not perfectly learn a programming language, libraries, and selected set of algorithms or specialized technologies. Of course, if pupils are asking for more challenging topics, we will be happy if a teacher is competent to teach them. But then, especially in relation to an evaluation of students, the teacher must realize that they are not compulsory components of school’s informatics.

Problems solving from the perspective of didactic of programming

Let’s imagine for example, that we are at the high school. Pupils have learned how to use variables and cycle. Pupils were training and using them to solve several tasks during preceding lessons.

Now, we want to teach to solve problems by accumulating result. We give pupils the following assignment: *"Cunning trader sells goods so that subtly increases its value. We pay 1 euro on the first purchase. On each latter purchase, he asks 1 euro more. How much would we pay altogether, if we bought goods 10 times?"* How should we proceed in class if pupils are not able to solve the problem by themselves?

It turns out that it does not enough to show pupils the solution, only:

```
s := 0;
for i := 1 to 10 do s := s + i;
```

It is because pupils do not understand to the given solution. For example, they do not understand how the assignment `s : = s + i` works. Even, additional explanations like *"it adds numbers from 1 to 10 to the variable"* will not help.

Moreover, pupils did not experience the process of solution inventing and they did not see how the program arose. Therefore they could not be able to solve similar assignments. If we continue to teach in this way and pupils stay in role of spectators, programming will happen to them a “magic”, which only masters the teacher. They get bored from the programming; they get frustrated because they actually do not know programming.

How can we proceed better?

First, we discuss with pupils about the assignment. We verify for example, if they understand it. Therefore we ask pupils: *"How much do we pay for the first purchase?"*, *"How much do we pay for the second one?"*, *"Third?"*, *"And the last?"*

We ask them further: *"How much money will we pay for all purchases together?"* In this case, the assignment has intentionally a trivial solution. So our pupils quickly reply that we actually need to sum the numbers:

```
1 + 2 + 3 + 4 + ... + 10
```

We will guide pupils to the informatics' solution: *"We could count the numbers by ourselves. But we have a computer. So, let computer add up numbers for us."* Our pupils do not know the mathematical formula for the sum of numbers, yet and we do not want to reveal it. We go further: *"We can't write the program as it is on the blackboard, because the computer can't guess what three dots ... means. We must list all the numbers."* Here we could end up, because the problem is solved. But this is this just the beginning.

Thus we continue: *"But let's imagine how the program would look like if we decided to sum up 1000 numbers. If we have to list all 1000 numbers, we would be tired. Can this be programmed somehow smarter?"* Now, we pushed pupils to their limits. Our motivation is based on the principle: we can solve the problem somehow, but the solution is awkward, so it does worth to learn something new.

Next we begin to examine the problem a little by better. The following analogy might help pupils: *"How would we sum the numbers without a computer?"* As teachers, we know that the final program will work in a similar way. Therefore, we want from pupils to discover that the solution is composed of a series of small steps.

We realize some steps together: *"First, we add numbers 1 and 2; then we add number 3; then 4, and so on."* In parallel, we illustrate each step, number and totals on the blackboard Fig.1.

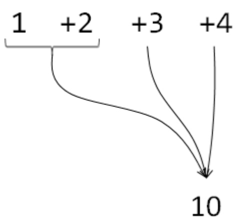

Fig. 1: Illustrations on the blackboard.

It is important for pupils to figure out that the result is produced gradually, not at one time. Moreover, the following scheme is discovering: *"We see that the sum is produced gradually. We add a number to the last result. It creates a new sum."* And further: *"We must remember the last result. Otherwise we would not know to continue counting. We wrote the result on the blackboard. Our program stores it using a variable. Let's call it for example* `s`*."* For pupils, it is important to experience the moment when the need to use a variable arises, and to understand the purpose for what the variables are used in final program.

Our illustrations on blackboard were yet informal. Now we bring them closer to the final program. *"In the beginning we have nothing. Therefore, after the program has started we set the variable* `s` *to zero"*. We are explaining and we are writing on the blackboard:

```
s := 0
```

We use familiar commands to write steps and we are verbally commenting them: *"Gradually, we add the individual numbers:"*

`s := s + 1` ... *"When this command executes the variable* `s` *will have a value 1."*

`s := s + 2` ... *„The variable* `s` *will contain value 3."*

`s := s + 3` ... *„*`s` *= 6"*

`s := s + 4` ... *„*`s` *= 10"*

...

`s := s + 10`

Such tracing, writings or drawings on the board are very important in order to give pupils the opportunity to discover the following repeating pattern: *"The first command* `s := 0` *is a special. But others look like this:* `s: = s + something`*. And the* `something` *changes from 1 to 10."*

Our pupils already know the programming construction of `for` loop and they have perfectly trained it. We ask: *"How to make a program that changes something from 1 to 10?"*

So we get to the notation:

```
s := 0;
for i := 1 to 10 do s := s + i
```

Next, pupils should train the new principle by solving similar graduated problems. For examples: Change the program to add up `100` numbers; to add up to *n*; Sum squares of numbers (`1 + 4 + 9 + 16 +` ...); Draw rectangles with sides gradually increased by 10; and other.

Note: sometimes it is not necessary to perform such detailed procedure. Some pupils need just a small hint. By contrast, with others we must go through all the steps with all 10 numbers.

Abstract reasoning in programming

We can see that by problem solving, we guide pupils to discover connections and relationships, to generalize solutions and to write their solutions using an abstract language.

It is interesting that by higher the level of abstraction we use notations which are shorter, but more difficult to understand.

For example, the sum of 10 numbers in Python programming language can be written as follows:

```
s = 0
```

```
for i in range(11):
      s = s + i
```

But also in this way:

```
s = sum(range(11))
```

It is possible that the notation `sum (range (11))` is still clear to us. But the principle that is behind it is far from simple.

For example, we can easily modify the solution with `for` loop to sum squares of numbers. Simply, we change the formula in the body of the cycle:

```
s = s + i * i
```

Can we write it using `sum (...)`? What should be in the brackets?

In teaching of programming, we must distinguish between different levels of demanding of concepts, problems, examples and solutions. Only then we can offer to our pupils an affordable way to new knowledge.

The ability of kids to think abstractly is determining factor in teaching of programming. For example, kids up to 12 years are in stage of concrete operations. The stage of abstract thinking starts later (Rybár, 1997).

This means, that under a certain age it does not make sense to expect from pupils a general solution (to use variables, or formulas with unknown values). Therefore, assignments for pupils at primary schools are formulated in such way that they work with a small number of specific elements, with pictures or objects that can be touched.

Cognitive process

We used the example with the sum of numbers in order to realise that a new programming knowledge is formed in certain stages:

Motivation

↓

Collecting own experience (elementary, then a little bit complex)

↓

Clarification of the rules and relationships (cleaning)

↓

Knowledge

↓

Crystallization (training of new knowledge)

These stages come out from constructivism, constructionism (Ackermann, 2010), theory of mathematics education (Hejný, Kuřina, 2009) and our observations.

Moreover, these stages are present when we teaching more challenging programming topics, even when we are teaching non-programming topics (for example, working with text or working with graphics). Also, our experience with professional teachers shows us, that they consider these stages as completely natural.

Pupils have different problems while learning a programming. For example, one research (Paz, 2006) discovered that some pupils have a misconception of variables. Consider the following example:

```
a := 1;
x := 2 + a;
a := 10;
```

Now, we can ask pupils what is the value of variable `x`? The correct answer is 3. But, some pupils may answer that the value of variable `x` is 12. From the perspective of didactics of programming we ask: *Why do they think so?*

Didactics of programming in teacher education

We have experience that general public usually underestimate didactics and teaching. We often hear opinions that *"didactics is useless"*, *"just use common sense"* and similar.

Even students – future teachers have a distorted idea about primary and secondary school, about pupils and teaching itself. This happens probably because these students experienced the teaching from one side only – as pupils.

Students – future teachers often do not understand that a good lesson is driven by certain rules. They underestimate preparation to teaching and to lesson. They significantly overestimate abilities of pupils. Students – future teachers do not believe that the children will not understand them, or children will not to perceive new concepts because of rapid pace.

Teaching of informatics and programming especially, consists a number of traps. A simply said: We know, how we shouldn't teach. But it is difficult to find the right approach - the right way.

We may conclude from the previous chapters that to teach a programming is as demanding as to teach math.

Our faculty has been offering some didactical courses for 25 years. But these courses were focused on general didactics, general pedagogy, advanced programming, or problems solving at level of various competitions. Therefore, it was decided more than 10 years ago that our students need a course of didactics of programming for ordinary pupils, in an ordinary classroom.

No such similar course of didactic we had found, therefore we had to design it from the scratch. We wanted to meet pragmatic expectations of our students: they would like to learn how to teach programming. Gradually, we have created a course which consists of minimum lectures about various theories. Instead of that we have invented a series of activities for our students that allow them to get experience with teaching of programming and to clarify very basic principles of teaching.

It was shown that activities should be arranged in such order that our students could gradually understand various didactical problems. For example, we observed that nearly all students initially do not understand to didactical problems related to teaching younger pupils. Probably, the age gap is too big and it is difficult to imagine for our university students a thinking of younger pupils. Therefore, we have tried to overcome the gap by familiarizing our students with didactical problems in reverse order: from higher secondary down to primary school.

So, the first activity of our course is focused on school-leaving test (maturation test) in informatics (*Monitor, 2004*). First, each student solves it. We want put our students in the role of their future pupils. Also we want to familiarize students with seriousness of the exam. We have observed that clever students consider that the test as very simple, some others as too difficult. A discussion about assignments, tasks follows then. We also focus on distinguishing and naming informatics' concepts that are tested in different questions, but also on a way that they are tested.

Previous activity gradually passes into debate about the national curriculum and the role and objectives of informatics and programming in education.

Another activity is focused on teaching a problem solving. We start with the cunning trader problem, as we have already described in this paper. At the beginning of this activity, we change roles. Students become teachers and they try to navigate us to the solution. We play a role of pupils who do not understand anything. Therefore we ask students: *"Where did this formula come from? For what is this variable? Why is this cycle there? How did it arise?"* During this "game", students realize that teaching is not a trivial task.

Subsequently, each student chooses some new assignment. He or she solves the assignment. Then he or she thinks about how to explain a solution to pupils. Finally, he or she demonstrates teaching in front of other classmates. Classmates are playing a role of pupils. This activity is funny and very edifying.

Our objective is to teach students to see the steps which lead to solution of a problem. Many students of our faculty are far excellent in programming. Schools programming problems are trivial for them and they solve such problems automatically, by heart. It is similar as to us to answer: *"How much is 100 – 50?"* Probably, we immediately respond that the result is 50. But pupils are taught the subtraction during several lessons of math in school. Therefore, we need these students to eject from such automatic mode.

During other activities: our students analyze and evaluate textbooks or books for professional programmers; we discuss about programming languages, about their advantages and disadvantages from a perspective of teaching; we discuss about different programming topics which are suitable for primary and high schools, students are taught to distinguish the stages of cognitive process (it is not easy for students).

At the end, students get recommendation how to teach individual programming topics; how to avoid didactical problems; or what examples and assignments are appropriate for pupils of various ages. Finally students present a lesson on a chosen topic. We and other students evaluate performance according to negotiated rules.

Conclusion

The goal of our school programming is to learn algorithmically solve problems. We have observed complex relationships in teaching of programming an age of pupils, their motivation; a choice of programming language and environment; order of topics etc. There are several publications that are focused on didactical aspects of programming (Armoni et al, 2010). We try to answer not only the question *"How to teach?"*, but also *"Why so teach?"*

We have argued in this paper that it is not easy to transfer didactical theories to future teachers. We must carefully choose those parts which our students are able to understand. Therefore we familiarize students with basic principles of teaching programming by performing many didactical activities. So, students by themselves gradually get to know the important moments of the teaching process. Not only positive, but also negative situations are valuable, such as: didactical problems caused by poorly specified assignment; lack of motivation; overcomplicated examples, usage of undefined terms during explanation of new concepts; or excessive ambition of teacher to solve complex tasks too early.

We have created a series of educational materials (Salanci et al., 2010) in which we have summarized or experiences from leading courses of didactics of programming that we developed within several years.

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PROGRAMMING WITH MOTION SENSOR USING LEGO WEDO AT LOWER SECONDARY SCHOOL

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Abstract

Educational robotics has become one of the popular and motivational tools of learning for mostly science and technology oriented classes. Its application in teaching specific subject is not very simple. Initiative teachers have encountered many questions, which include the selection and development of specific types of activities that can allow students to extensively utilize the potential of the selected robotic kit. In our research we have been working with educational robotics in informatics at lower secondary school. In this paper we focus on the fifth grade students, which worked with robotic kit LEGO WeDo. We analysed different types of activities, where pupils were programming the robotic model with usage of motion sensor. Our aim was to identify what types of activities the pupils resolved correctly and in what types of activities pupils most often made mistakes. In pursuit of that, we can create a more concise and easier to understand version of tasks to program the robotic model. These activities are part of the curriculum with educational robotics, which we have been developing within our doctoral research. We have been conducting design base research within we chose qualitative methods of data collection and data analysis. Based on data analysis, we found that in most cases pupils solved prepared tasks, in which they worked with programs from the worksheets (modifying the program, explaining the differences between the two programs and completing programs). Pupils mostly made mistakes in explaining a particular program and in creating a certain sequence of commands in program. In the next phase of our research we are going to modify mentioned activities so pupils can better acquire problem solving skills, programming skills and communication and collaboration skills.

Keywords

educational robotics, robotic kits LEGO WeDo, activities with motion sensor, lower secondary school

Introduction

In many countries educational robotics increasingly occurs from preschool to university courses (Cappelleri, Vitoroulis, 2013; Detsikas, Alimisis, 2010; Benitti, 2012; Bers et al., 2014). Researches and teachers have been trying to motivate students to learn mostly science and technology classes and there students can acquire and develop for example problem solving skills (Hussain, Lindh, Shukur, 2006; Sullivan, 2011; Castledine, Chalmers, 2011; Denis, Hubert, 2001), programming skills (Atmatzidou, Markelis, Demetriadis, 2008; Burbaite, Stuikys, Marcinkevicius, 2012), creativity, communication and collaboration skills (De Michele, Demo, Siega, 2008; Demo, Siega, De Michele, 2009). Application of educational robotics in teaching specific subject is not very simple. Initiative teachers have encountered many questions, which include the selection and development of specific types of activities that can allow students to extensively utilize the potential of the selected robotic kit. In our research we have been trying to integrate educational robotics into informatics at lower secondary school.

Research methods

In this article we describe different types of activities with selected robotic kit LEGO WeDo, in which we focus on programming robotic model with motion sensor. These activities are part of our curriculum with educational robotics, which we have been iteratively developing during our doctoral research. In activities with motion sensor we used qualitative data collection and data analysis (Švaříček et al., 2007) including observations (fieldnotes and transcriptions), audio-visual materials (photographs and recorded videos of pupils' work and pupils' products). We conducted our research with two classes of fifth grade pupils at lower secondary school in Stupava (small town near the capital city of Slovakia). At first we designed activities with educational materials. We created methodological materials for teacher and worksheets for pupils. Afterwards selected teacher taught her pupils according our materials – one lesson per week. There were approximately from 10 to 11 pupils in one class – boys and girls in different ratio each week. During all of these classes with robotic kits there were present also two researchers, who were collecting data.

Motion sensor in robotic kit LEGO WeDo

During designing activities with motion sensor we were examining its properties, functionality and different ways to program robotic model with it. LEGO Education WeDo Construction Set includes carefully selected bricks in different colour, gears, axles and pulleys, which can bring motion to models, special components, such as rope and elastic bands, which can increase varied range of models pupils can create and two minifigures. There are also Power Functions M Motor, two sensors (motion sensor and tilt sensor) and WeDo USB Hub. It controls motor and sensors via software for WeDo robotic kit, when it is connected to a computer. Motion sensor can detect objects within 15cm range (The LEGO Group, 2015). It is automatically detected by software, when we connect it with USB Hub to a computer (see Figure 1).

Fig. 1: Connection of motion sensor in software for LEGO WeDo robotic kit

We provided description of software environment for LEGO WeDo in (Mayerová, Veselovská, 2014). Here we focus primarily on types of activities within programming with motion sensor. In this software motion sensor is located in the form of parameter, which can be represented by integer or state. Value of motion sensor parameter can acquire integer value from 0 to 10 (0 – object is further than 15 cm from sensor, 10 – object is right in front of sensor). On Figure 1 we can see sensor, which detects object at a distance of nearly 15 cm and parameter of motion sensor contains an integer value 1. Value of motion sensor parameter can also have two states: it does detect a movement and it does not detect a movement. It is not dependent on whether motion sensor detect object or not at the first time. We can use this parameter in different ways and in mentioned software it can be connect with various icons of commands. On Figure 2 we can see five icons of commands (motor power, sounds, display text on computer screen, display background on computer screen, add value of number to display), connecting with them parameter can contain integer value.

Fig. 2: Icons with motion sensor as a parameter with integer value

On the left of Figure 3 we can see three icons of commands, connecting with them parameter can contain two states. These icons are representing from left:

- motor on until sensor detect motion,
- wait until sensor detect motion,
- count loops (a loop with a known number of repetitions, but without an explicit loop variable) until sensor detect motion.

These commands can be parameterized to produce different behaviour of robotic model / program (on the right of Figure 3). These icons are representing from left:

- motor on for ten periods of time (we labelled it as ten LEGO seconds),
- wait for ten LEGO seconds,
- count loops with three repetitions.

Fig. 3: Icons with motion sensor with state parameter (on left) and same icons with integer value as a parameter (on right)

When we were designing activities with motion sensor, we were carefully creating and selecting tasks for pupils. We tried to prevent possible misconceptions with application of known icons of commands (icons previously connected with integer value as parameter). At first pupils worked with these icons of commands with motion sensor as parameter, where it can acquire integer value. So this motion sensor as a parameter worked like known integer value as parameter. And later pupils worked with combination of icons with motion sensor as parameter, which can acquire a state value.

Activities with motion sensor

Activities with motion sensor are part of our curriculum with educational robotics, which currently has 12 lessons (one lesson = 45 minutes, one lesson per week). During all these activities pupils were working in pairs (alternatively one pupil worked alone, when there was uneven quantity of pupils). Before activities with motion sensor we had been conducting four lessons with pupils. During first three lessons pupils had clarified a term of robot, constructed robotic models according building instructions and examined basic icons of commands (icons for motor control and icons, which play sound) in software. In fourth lesson we had followed principles of "creative robotics for all" (Rusk et al., 2007):

- focus on theme,
- combine art and engineering,
- support storytelling,
- organize exhibitions.

During this lesson pupils had created their own robotic models and their own programs for controlling them. Then we were conducting activities with motion sensor, which we had divided into three lessons. We can see specific types of tasks with motion sensor in Table 1. We divided these activities into three categories, which include constructing robotic model, programming robotic model and presenting robotic model. Then we evaluated pupils work according these three categories.

	Types of tasks with robotic model		
	Programming	**Constructing**	**Presenting**
1. lesson	Acquaintance with different ways of usage motion sensor	Build a model according instructions in worksheet	Explain your work to teacher
	Describe the behaviour of the model (describe the program)		
	Create a program exactly as ordered		
Bonus	Create your own program with specific icons: loop, motor power, motor on for, sounds, motion sensor	Edit a model according to your imagination	Explain your work to teacher and your classmates
2. lesson	Create your own program with icons: loop, motor power, motor on for, wait, motion sensor	Create your own model with motor and motion sensor	Explain your work to teacher and your classmates
3. lesson	Describe the behaviour of the model (describe the program)	Create part of model with motion sensor according a picture in worksheet	Explain each task to teacher
	Change program as ordered		
	Describe the differences in the behaviour of the model in the control of program A and program B	Complete model to contain the motor	
	Complete program by request		
Bonus	Create your own program		Explain your work to teacher and your classmates

Tab. 1: Different types of tasks with robotic model

First lesson with motion sensor

At the beginning of the first lesson selected teacher started with frontal form of teaching, where she was asking pupils open questions, for example: *"Do you know how motion sensor looks like? How can we connect motion sensor to computer? Which icon is representing motion sensor in software? With which icons can we connect motion sensor? How many are there? …"*. These way pupils could have feedback from teacher almost immediately and also they could discuss it with their classmates. This part of the lesson is marked as ***Acquaintance with different ways of usage motion sensor*** in section *Programming* of Table 1. Then pupils were building robotic model according instructions. We can see final model on Figure 4.

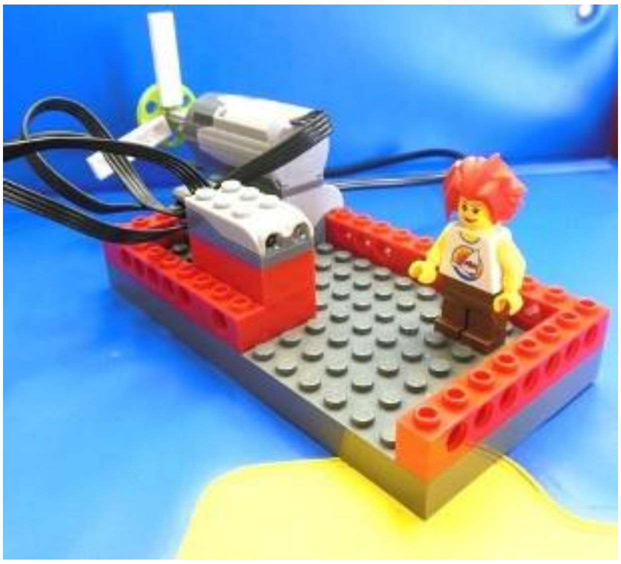

Fig. 4: Robotic model, which was built according to instructions

Subsequently pupils were programming robotic model according two different types of tasks in worksheet (column *Programming* in Table 1):

- they were describing the behaviour of the robotic model - describe the program.
- they were creating a program exactly as instructed.

Also we can see examples of mentioned tasks on Figure 5. In first example (in top of Figure 5) pupils were describing the behaviour of the robotic model to teacher and they were also writing it down into worksheets. In second example pupils were creating program according instructions in worksheet. We can see final program is in the bottom of Figure 5.

Fig. 5: Two programs from two different types of tasks from worksheet

During this lesson pupils can also work on Bonus task, in which they were creating their own program, but with specific icons: loop, motor power, motor on for, sounds, motion sensor.

Second lesson with motion sensor

In this lesson we followed principles of "creative robotics for all" (Rusk et al., 2007), which we mentioned earlier and some constructionist ideas (Papert):

- learning by doing, hand-on activities,
- genuine achievement and own solutions, problem finding,
- hard fun and playful learning,
- learning through designing and creating,
- freedom to make mistakes,
- teamwork, communication, collaboration, sharing work and ideas.

During this lesson pupils were building and programming their own robotic models with some specific conditions within the selected theme **Intelligent servant**. Robotic model should contain motor and motion sensor. Program to control robotic model should contain selected icons of commands: loop, motor power, motor on for, wait and motion sensor. Pupils could connect motion sensor with each of selected icons, but minimum was connection of motion sensor and one of mentioned icons. At the end of lesson pupils was presenting their robotic models and programs to teacher and classmates. Pupils had to introduce a name of robotic model and they had to explain its purpose and behaviour. We can see examples of pupils' robotic models on Figure 6 and their programs on Figure 7.

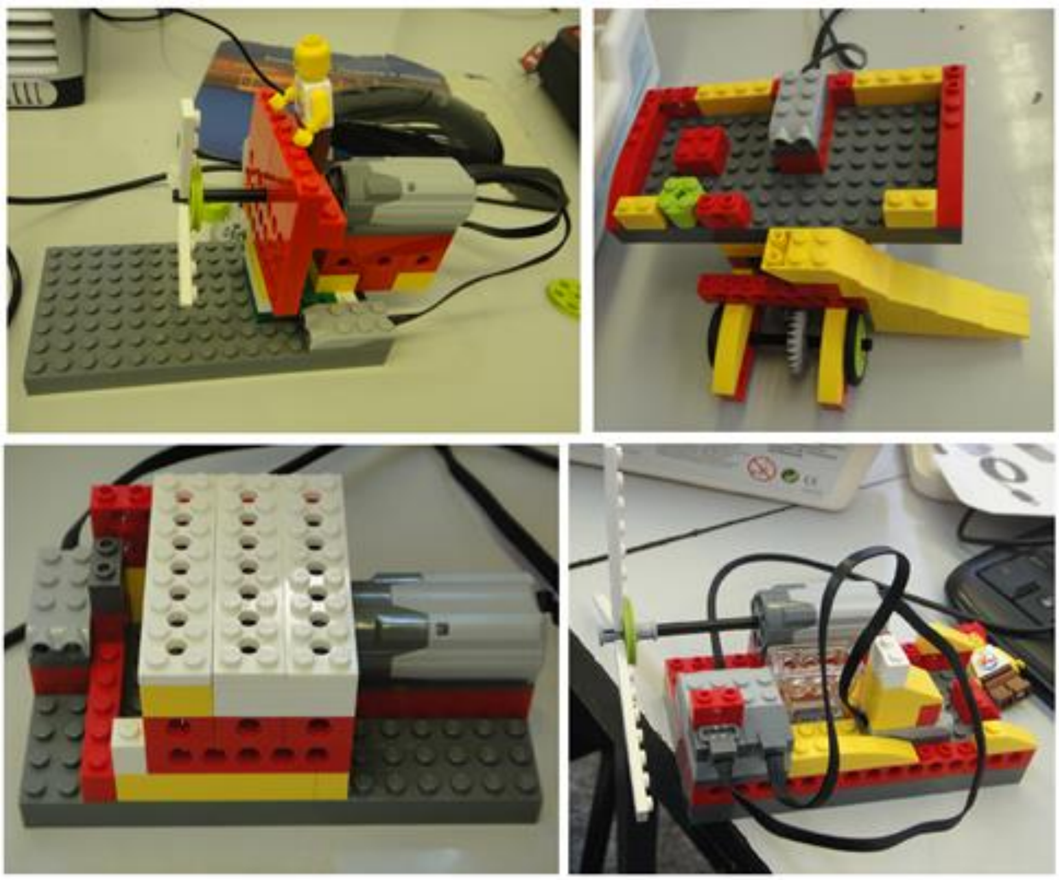

Fig. 6: Pupils' original robotic models, which they constructed within selected theme Intelligent servant

Fig. 7: Pupils' own programs to control behaviour of their robotic models

Third lesson with motion sensor

During third lesson pupils were building part of the robotic model with motion sensor according a picture (on the left of Figure 8) and then they were completing robotic model according their imagination, but with a one condition: robotic model should contain also motor. We can see example of final robotic model on right of Figure 8.

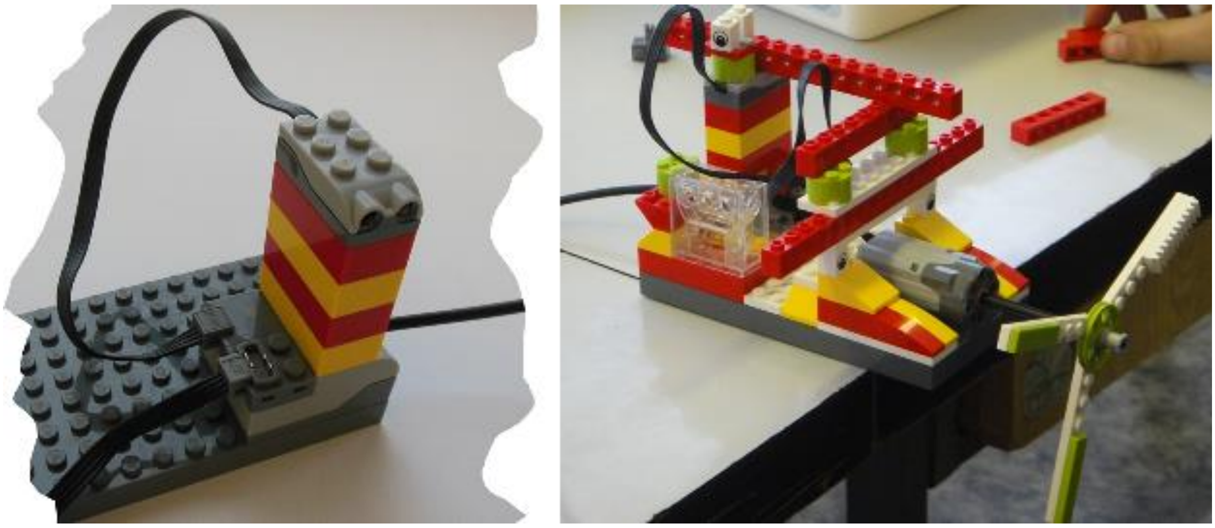

Fig. 8: Part of robotic model (on left), final robotic model (on right)

Afterwards pupils were programming robotic models according four various tasks in worksheets (column *Programming* in Table 1):

- they were describing the behaviour of the model (they were describing the program),
- they were changing program as instructed,
- they were describing the differences in the behaviour of the model in the control of program A and program B,
- they were completing program by request.

During this lesson pupils can also work on Bonus task, in which they were creating their own program without any conditions.

These tasks should provide some clarity of usage several types of icons connected with integer value as a parameter and with motion sensor as a parameter.

Example of one task from worksheet:

Describe the differences in the behaviour of the robotic model in the control of program A and control of program B (on Figure 9).

Fig. 9: Example of programs from worksheet, where pupils described differences between these programs

Correct solutions and identified mistakes

Based on data analysis we concluded that in most cases pupils solved correctly prepared tasks, in which they worked with programs from worksheets:

- modifying the program,
- explaining the differences between the two programs,
- completing programs.

We can see examples of final programs from task with modifying the program on top of Figure 10 and we can see example of program from task with completing programs on bottom of Figure 10. We can see example of programs from worksheet, where pupils described differences between these programs on Figure 9.

Fig. 10: Correctly modified program (on top) and correctly completing program (on bottom)

Pupils mostly made mistakes in explaining a particular program and in creating a certain sequence of commands in formed program. For example pupils were describing program, which we can see on bottom of Figure 11.

Fig. 11: short program (on top) and longer program (on bottom), with which pupils were describing behaviour of robotic model

In mentioned program pupils often did not describe each icon of commands:

"Motor was spinning, then it was waiting for 20 LEGO seconds and then it was turning to other side."

"Motor was turning right with its power 7 and for 10 LEGO seconds, then motor was waiting for 20 LEGO seconds."

"Robotic model was turning right with power 7 and for 10 LEGO seconds. Then it was waiting for 20 LEGO seconds. Then it was turning left for 10 LEGO seconds and then motor stopped."

As we can see pupils did not describe all icons of commands in program. They did not describe:

- some of lasts icons of commands,
- some of icons, with which we can set direction of rotation of motor, motor power and motor on for specific number of LEGO seconds,
- icon of display text on computer screen.

When pupils were describing short program such as on top of Figure 11, they created imprecise descriptions, for example:

"Motion sensor adapts to the speed of motor."

"When sensor detects minifigure, motor started to spin."

Pupils made mistakes, when they were explaining not only programs from worksheets, but even when they were explaining their own programs. One team of girls was describing their program, which we can see on bottom of Figure 6 such as:

"When we run the program, minifigure starts to put clothes to washing machine. So motion sensor detects minifigure and washing machine start to wash. It will stop, when minifigure go away."

This team described their program completely incorrect. At first they did not describe icons of commands in their program precisely and they did not describe behaviour of their robotic model at all. One of correct explanations of their program could be:

“When we run the program, washing machine starts to wash in one direction and its power basis on minifigures distance from motion sensor. When motion sensor detects motion again, washing machine starts to wash in other direction and also we can hear a sound basis on minifigures distance from motion sensor. This repeats twice.”

When pupils were programming robotic model according the tasks in worksheet, they were creating incorrect sequence of icons and they were not using all icons within the particular task. When pupils were programming their own robotic models, they did not use all required icons (they did not use loop or motor on for), because they wanted to create their own program according only to their imagination. We can see examples of pupils programs on Figure 7.

How programming robotic model can achieve educational aims of informatics in Slovakia?

Within programming robotic model pupils could acquire problem solving skills and programming skills. Pupils used programming language to define robots’ behaviour, so they applied the rules on the construction of a simple educational programming language for robotic kit LEGO WeDo by direct manipulation of icons of commands assembled into sequence.

Pupils:

- evaluated this sequence of commands,
- found mistakes in sequence of commands,
- modified sequence of commands.

They also interpreted the differences between two various sequences of commands and they specified integer number of repetitions of particular sequence of commands.

Conclusion

In this article we described various types of activities with motion sensor, which are part of our curriculum for educational robotics at lower secondary school. We divided these activities into three lessons and we provided list of different types of tasks within each lesson. In data analysis we focused on various types of tasks with programming robotic model. We identified types of tasks, where pupils created correct solutions and types of tasks, where pupils made mistakes. In next phase of our research we are going to modify mainly types of tasks, where pupils mostly made mistakes and also we are going to edit whole activities, so for example pupils can better acquire problem solving skills, programming skills and communication and collaboration skills. We believe that our iteratively created activities for educational robotics will serve mainly for achievement of educational aims in informatics at lower secondary schools in Slovakia and they will serve for development of various important knowledge, ability and skills, which pupils can use not only at school, but even during leisure time activities.

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LEARNER-CONTENT INTERACTION IN FLIPPED CLASSROOM MODEL

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Abstract

The article deals with the interaction of elementary school students with online educational videos. Half-yearly survey was conducted in mathematics lessons pupils in the eighth grade. During the experimental teaching was flipped classroom teaching model, where students watch educational instructional video before school lessons. During class when the teacher uses activization teaching methods that build on the content of the educational video. It turned out that there is a correlation between the average length of time that students watched videos and length instructional videos. Students watched a video about three times the length of their time. Additionally was monitored a number of playback of educational videos. Here it shows a slightly declining and fluctuating trend. For some video, especially towards the end of the experiment, the number playback are low due to preservation the measured correlation. This suggests that some students stopped to watch educational videos at the end of the experiment or accelerated video playback.

Keywords

flipped classroom, learner-content interaction, educational videos, elementary school

Introduction

All around as what we can know is changing dramatically, and pedagogy too. With new technologies and increased understanding of cognitive development, teachers have to be open to changes and improvements in their classroom instruction. One pedagogical response to the growing interest in technology in the classroom is the flipped classroom.

Flipped classroom model

The concept of Flipped / Flip / invert classroom appeared in educational research a few years ago. Due to the limited amount of research there is little consensus on the complete definition of this concept. Lage (2000) defines the inverse of the class as follows: "Upside class means that the events that traditionally took place in the classroom, takes place outside the classroom and vice versa." This explanation captures the reasons for use of terminology flipped classroom. This definition would mean that the flipped classroom represents only change the arrangement of learning activities. Most research deals with the inverse class activity methods in the classroom. There are quoted on a student-oriented learning theory based on the works of Piaget (1967), Vygotsky (1978). The flipped classroom most uses asynchronous online courses, which are shared via the web interface study materials, most educational videos. From this point of view, the inverse class rather extension of the curriculum, rather than just a new way of working. Since 2013, the academic work is the concept of inverse model class.

Parent category to flipped classroom is blended learning, which can be translated as computer-aided instruction. Skater (2012) defines a "blended learning" as an educational program in which the student learns partly by on-line learning materials and individually checked their education and partly educated in school under the supervision of a teacher.

Flipped classroom uses implementation rotation-model in the learning process when certain procedures are repeated cyclically which means:

- The teacher outside the school prepares on-line study materials instead of interpreting the new school curriculum.
- Students will get acquainted with the new curriculum through on-line learning materials, and thus control their own education.
- The teacher in school activities prepared in accordance with activation methods of teaching, during which students discuss and practice the new curriculum.
- During lessons are used personalized and activization methods of teaching.

So it works with the definition of flipped classroom as methods of teaching, which is cycled through the above points (1-4). Study of George Mason University and a Pearson company defines four pillars on which the reciprocal class built:

- Teachers introducing reciprocal teaching class in its sole discretion, which combine different methods and forms of teaching according to students' needs.
- Teaching is focused on students. The teacher becomes a creative activity in which students are actively manage their education.
- The teacher uses appropriate on-line learning materials to help students understand curriculum.
- The teacher's role is irreplaceable, while providing feedback and individual approach to students in the learning process.

Furthermore, these studies describe the increase in interest the flipped classroom and presents qualitative data, according to which the majority of teachers and students with this way of teaching satisfied. In his dissertation Strayner (2007) describes the effect of the flipped classroom on learning environment on college students in course of statistics, which compares with the study environment in the traditional method of teaching. Works of Moravec et al. (2010) and Day and Foley (2006) dealing with academic performance of students using the flipped classroom model. In both studies, flipped classroom students achieved significantly significant better results than students taught by traditional method. So far it is not known to many research papers flipped classroom of an elementary school. This method involves interchanging typical classroom tasks with homework tasks. Instead of taking class time to demonstrate math processes, teachers record their lectures and assign students to watch the lecture videos as homework. The flipped model allows active learning to take place in the classroom during class time. This technique allows teachers to be present when students run into difficulties as they apply what they are learning to solving problems; instructors can hear and correct misunderstandings the moment they occur.

Today students can call net generation spend a lot of time connect on internet. Using technology also needs to be conducive in the environments in which students complete their work. Furthermore, students must have the necessary motivation to benefit from this technique. Some studies have explored the benefits of the flipped classroom, the study environments of students, and student motivation for using technology. The goal of this study was to map student interaction with instructional videos during their home preparation on lessons.

Types of Interactions

Before the explosion of online teaching and learning, Moore (1989) offered classification of interactions in education. His three-part interaction scheme included:

- learner-instructor
- learner-learner
- learner-content interaction

Learner-instructor interactions establish an environment that motivate learners to understand the content. This type of interaction is “regarded as essential by many educators and highly desirable by many learners”. Learner-learner interactions take place “between one learner and other learners, alone or in group settings, with or without the real-time presence of an instructor”. Some studies show that this type of interaction is a valuable experience and learning resource (Vrasidas & McIssac, 1999). Learner content interaction is defined as “the process of intellectually interacting with content that results in changes in the learner’s understanding, the learner’s perspective, or the cognitive structures of the learner’s mind” (Moore, 1989). Although learner-content interaction is well recognized as a type of interaction, there is not much discussion about learner-content interaction in the current literature. This is probably because different contents may require different interaction patterns, and, thus, it is difficult to have a generalized discussion about such interaction. Given the technology-mediated nature of online education, learner-interface interaction is considered to be another important type of interaction. Hillman, Willis and Gunawardena (1994) point out that this type of interaction occurs between the learner and the technology used for online education. She further points out that it can be one of the most challenging types of interaction due to the fact that people have not experienced having learner-interface interaction in their traditional classroom education. There are some other types of interactions that are not as widely discussed such as vicarious interaction and learner-self interactions. Moore (1989) argues that it can be treated as an essential part of the learner-content interaction. However, scholars coming from a sociocultural perspective which emphasizes self-talk as a means of internalizing strategies witnessed on a social plane would likely differ with Moore on this issue. It is not the focus of this study to explore which classification is correct or easier to identify. Through documenting some of the literature about interaction, researchers hope to demonstrate what instructional activities and technologies are used in practice to enhance interaction in general and how students and instructors feel about these interactions. For the purposes of this article, will be discuss the Learner-content and learner-interface interactions. Wagner (1994) use term interaction for communicative relationships between human beings. For learner content-interaction, where is today content is mostly represent online educational materials is used term interactivity. The majority of student time, in all forms of education, is consumed by interactions with a variety of educational content. In distance education, this has meant study with texts and electronic resources, often supplemented created study guides. Current technologies provide a wide variety of media alternatives for creating content for student interaction. This study focus on the time spent by students during homework, watching educational videos and their subsequent activity in the classroom, which is used by educational flipped classroom model.

Methodology

For examining the interaction between students and online instructional video was used long term classical pedagogical experiment. During this experiment was also investigated the academic performance of pupils. We worked with the control and experimental group (always one class of the same school year). Pedagogical experiment was attended by 54 students, 27 in the control and experimental class. The control group of pupils progressed by traditional teaching methods, especially new exposition of the new curriculum took place during lessons. The experimental group had available educational videos that was specially created for the purpose of the experiment. For distribution educational videos were created websites (prevracenatrida.cz). There were also explain, what flipped classroom teaching method is. Students watched video during home preparation. They had the opportunity to comment each video and discuss the problematic part of the matter on the social network. Brief summary of the topic and explanation of the problematic parts was performed in classes. Emphasis was placed on independent work and deepening knowledge. At the beginning of the experiment the control and experimental group went through a didactic test (pre-test). In the middle of experiment students pass intermediate test. At the end of the experiment both groups then passed another didactical test (post-test). Twenty-five educational videos were created that cover the mathematics curriculum first half of the eighth grade. The researcher was also a math teacher for the experimental group. Partial results of the research have been published (Špilka & Maněnová, 2014).

During the pedagogical experiment was recorded using an algorithm frequency and duration playback of educational videos on the web prevracenatrida.cz. The number of visitors and the playing time of each video was recorded by students of the experimental group.

Results

We were interested in the relationship between the average time video playback and length videos. We assume that if students use educational videos for self, should confirm the relationship between the playback time and total length videos. Based on this reasoning, we have set the following hypothesis:

H: We assume the dependence between the video length and the average playback time of each video by experimental group student.

Table and chart compares the length of the instructional video and an average playing time of each video for the experimental group of students.

	v1	**v2**	**v3**	**v4**	**v5**
Educational videos length	4:13	5:00	4:49	8:07	2:13
Average playback time	16:13	13:41	14:27	20:46	9:27
	v6	**v7**	**v8**	**v9**	**v10**
Educational videos length	3:36	5:10	4:38	6:34	4:12
Average playback time	10:02	16:29	14:41	18:23	14:34
	v11	**v12**	**v13**	**v14**	**v15**
Educational videos length	3:00	3:44	5:24	3:26	5:23
Average playback time	12:36	11:19	12:47	12:23	16:09
	v16	**v17**	**v18**	**v19**	**v20**
Educational videos length	4:27	5:36	2:06	3:06	3:46
Average playback time	13:58	15:31	8:49	10:04	14:42
	v21	**v22**	**v23**	**v24**	**v25**
Educational videos length	3:45	3:56	1:51	5:20	4:49
Average playback time	15:16	14:26	9:36	16:21	15:32

Tab. 1: Time data about video length and average playback time

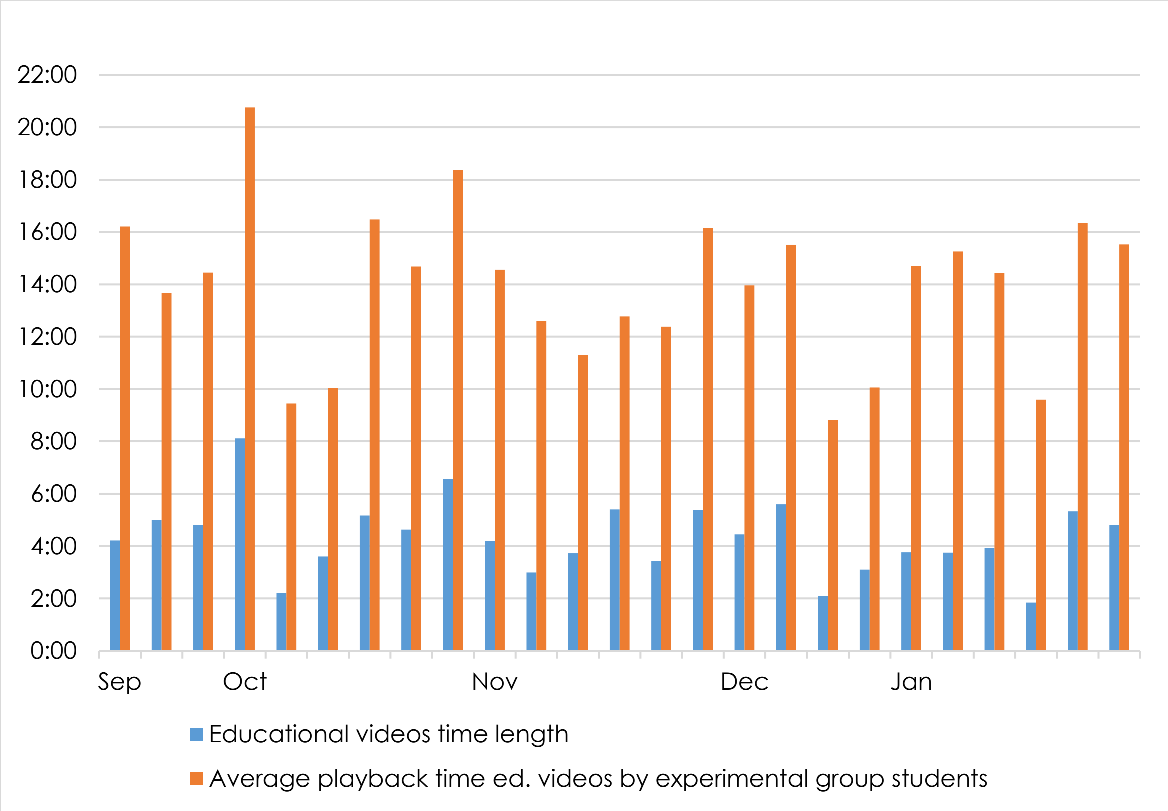

Fig. 1: Compare educational videos length and average playback time

Because normality tests clearly did not confirm the normality of the data examined (normality of the data was verified by Kolmogorov Smirnov test, D'Agostino Skewness tests, D'Agostino and D'Agostino Kurtosis Omnibus) for testing we used Spearman's test. We tested at a significance level $\alpha = 0.05$. Spearman correlation coefficient was 0.7998. It was then proved a relationship between the educational video time length of the video and the average playback time of each video for students of experimental groups (Fig. 2).

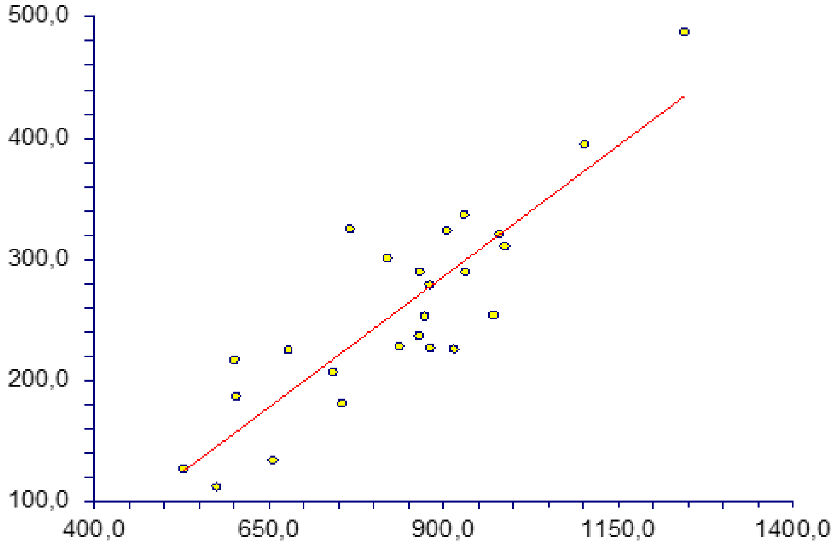

Fig. 2: Correlation educational videos length and average playback time

We also monitored the number of plays each videos. In Figure 3 we see a graph with a slightly downward trend.

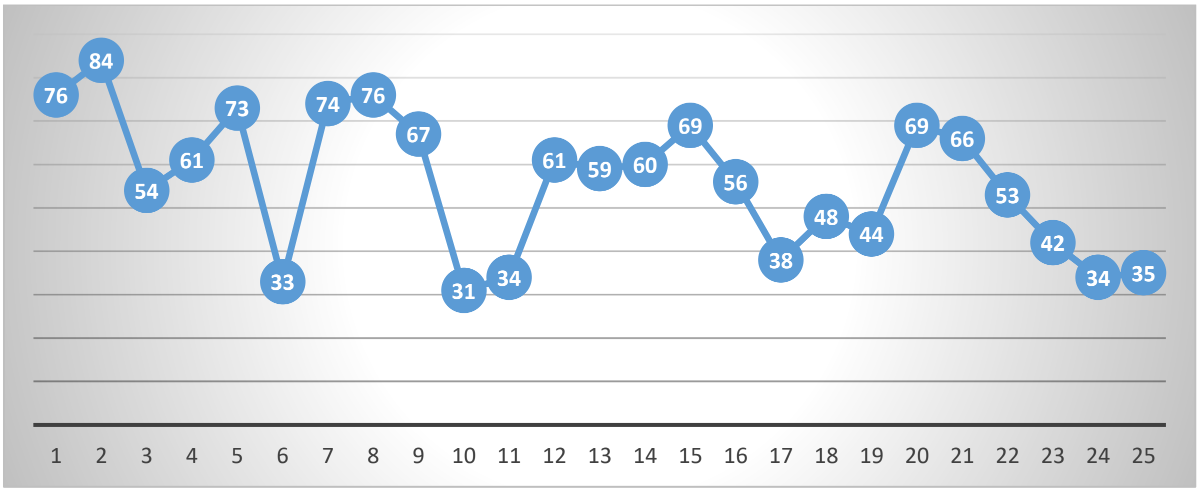

Fig. 3: Number of plays each video

Discussion

Research issues related to learner-content interaction is focus on the development and evaluation of new forms and tools of learner-content interaction. The results will be used to assist developers and tutors in both creating and modifying existing objects and in selecting and assigning the most appropriate sets of learning activities based on learner-content interaction. An added benefit of the rich resources available will be the growing capacity to design multiple paths through content based on a variety of learning needs and preferences. Finally, the shared environment of web-based education allows for rapid inclusion of student-created content and its incorporation into current and subsequent versions of education courses. This research works with small research sample, so conclusions cannot be generalized. Then there is excluded the interaction of students, which constitute an integral part of the educational process. However, it demonstrates one of the ways to explore independent pupils' homework.

Conclusion

This study shows how pupils of elementary schools working with online educational materials. In the case of educational videos correlates exists between the length of instructional videos and playing time. If we look at the frequency playback instructional videos and these data we put into the relationship, and the average length of video playback time can partially understand the behaviour of students during homework. For some video, especially towards the end of experiment, the numbers of the playback ae low due to preservation the measured correlation. This suggests that some students stopped watching educational video during the experiment. Some students watched a video approximately three times their length. For further research would be useful to find out whether the time spent with video affects their academic performance.

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QUALITY OF HIGHER EDUCATION AND STRUCTURE OF ICT COMPETENCE OF TEACHERS IN UKRAINIAN HIGH SCHOOLS

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Abstract

This article examines ways of improving the quality of higher education in Ukraine in context of European quality standards for University educational space. The European standards and guidelines are considered in relation to internal quality assurance. The paper describes interdependence between the education quality of the University and the ICT competence's level of its educators. It presents the indicators to achieve internal quality standards in educational process. There are results from the questionnaire of the Borys Grinchenko Kyiv University's educators about dependence between the level of educators' ICT competency formation and the quality of educational services. We describe the model of ICT competence corporate standards for the educators developed in the Borys Grinchenko Kyiv University. There are also presented the indicators and tools to measure the level of educators' formation in the corporate standards.

Keywords

quality of higher education; ICT competence; corporate standards; measurement tools

Introduction

Problem statement. European integration process, which is now taking place in Ukraine, accompanied by the formation of a unified educational and scientific space, which, in turn, on the necessity for the development of common standards and criteria for evaluating the quality of educational services. The legislation of European integration processes in Ukraine secured certain laws and regulations. However, the issue of quality in higher education remains open, relevant and provides different ways to solve specified in the new Law on Higher Education (2014).

The European education system is focused on the skills of the 21st century and is labile under the influence of modern macro trends: globalization, demographic change and the emergence of new knowledge and competencies. Macro trends occur under the influence of the rapid development of technology that affect business development, labor market and, in turn, to a system of higher education should prepare graduates for today's conditions - graduates with new competences and new professions [2]. And therefore these competences and teachers should possess a modern university, which is currently in the competitive environment of the MOOC.

Analyzing the European standards of higher education and the impact of macro trends in the education system and its transformation can hypothesize about the dependence of the quality of educational services on the level of formation of the ICT competence of the teacher.

The purpose of this article is to describe the developed model of corporate standard of ICT competence of university lecturer, built with consideration an appropriate framework of ICT competence of UNESCO and the results of a survey of teachers of the Borys Grinchenko Kyiv University.

Analysis of recent research and publications. The issue of quality in higher education studied D. Green, K. Negri, J. Ojasalo, M. Kisil, H. Krasilnikova, N. Sukhova [28], N. Statinova [27]. John Bailey, Nathan Martin, V. Kuharenko note on the impact of macro trends in higher education system [2]. Monitoring the quality of higher education explore Carole Webb, Jim Finch, Malcolm Frazer, V. Luhovyi, Z. Taranova, I. Annenkova. Standardization of ICT in education investigating K. Aesaert, Kozma, Robert B., Wayan Surya Vota Yoshiki Sakurai, V. Bykov, M. Zhaldak, V.K uharenko.

Analysis of the Standards and Guidelines for Quality Assurance in the European Higher Education [11] noted that the main activities of teacher in the modern university should focus on creating high quality content and use educational environment, including electronic. The impact of technology [2] on the occurrence of macro-trends and reform of higher education in Ukraine supports the hypothesis urgent development and implementation of standards [15] information and communication competence of teachers in terms of European integration processes of modern higher education. The issue of monitoring these standards is important from the perspective of improving the quality of education and university achievement of European indicators of quality of higher education.

Result of research

The quality of higher education

Quality of education is the balanced line (as a result, the process of the educational system) identified needs, goals, requirements, rules (standards). The components of the quality of higher education is to provide training, research and teaching staff, material and technical resources, educational environment, including electronic, educational achievement of students, the system of education management and research results [15]. Ukrainian system of quality assurance based on the day of the administrative-command methods [20]; consumer of such a system was the state. Therefore, the principles of management of higher education in Ukraine and its quality indicators today are administrative as university funding (excluding private) it was possible to adopt a new law on higher education with a budget.

The European education system - on the contrary, formed under natural choice when quality requirements of education put forward directly to consumers' educational services - sectors, employers, students. Standards and Guidelines for Quality Assurance in the European Higher Education consists of three aspects: European standards and guidelines for internal quality assurance in higher education, European standards and guidelines for external quality assurance of higher education and European standards and guidelines for agencies external quality assurance [11].

In the context of the purpose of this article we consider the structure of the European Standards and Guidelines for internal quality assurance in higher education institutions (European Standards and Guidelines, ESG) (Table 1), and we have developed indicators to measure them (30).

Standard	**Guidelines**	**Indicators of measurement (30)**
1.1. University policies and quality assurance procedures	Institutions should determine the policy and related procedures to ensure the quality and standards of their training programs and diplomas. To achieve this goal, they should develop and implement a strategy for the continuous improvement of quality. The strategy, policy and procedures should have a formal status and be available to the public	• I11: availability of educational policy • I12: internal ratings University to implement research activities • I13: open scientific resources • I14: results of the survey of students • I15: corporate standards • I16: implementation of quality management system of ISO 9001
1.2. Position to approve, evaluation and monitoring of programs and qualifications	Institutions should have formal mechanisms approval, periodic review and monitoring of their training programs and diplomas	• I21: description of the expected learning outcomes • I22: availability of curriculum • I23: availability of training programs • I24: availability of different forms of learning • I25: educational materials for training courses • I26: availability of electronic register • I27: existence of a special (external) quality evaluation commission curricula

1.3. Assessing students' knowledge	Attendance requires consistent use of published criteria, regulations and procedures	• I31: existence of a special structural unit dealing quality • I32: systematic monitoring of student learning outcomes •
1.4. Quality assurance of teaching staff	Institutions should have the specific procedures and criteria to certify that teachers who work with students with appropriate qualifications and high professional level to carry out their duties	• I41: survey of teachers • I42: availability of ICT competency standards for teachers • I43: open portfolio of teachers • I44: open portfolio of teachers • I45: system of teacher training • I46: system of rating the performance of teachers
1.5. Learning resources and student support	Institutions should ensure that available resources that provide training process are adequate and correspond to the content of the programs offered by the institution	• I51: the availability of educational materials at anytime and anywhere placing material on the Internet (centralized or decentralized components of ITS) • I52: accounting student learning styles: presentation training materials in various forms (audio, video, tables, plain text, diagrams, etc.) • I53: the needs of students in the use of electronic resources and services included in personal electronic educational environment of students • I54: monitoring the quality of electronic educational resources • I55: monitoring the level of satisfaction of students providing electronic learning materials
1.6. Information Resources	Institutions should ensure that they collect, analyze and use relevant information to effectively manage their training programs and other activities	• I61: records of all activities of students • I62: accounting student learning outcomes • I63: availability of special structural unit on employment of graduates • I64: availability of public information about the teachers • I65: availability of public information about accreditation and its performance

		• I66: availability and openness of e-performance qualitative and quantitative indicators of accreditation of all specialties
1.7. Publicity information	Institutions should regularly publish the latest, unbiased, objective information - both quantitative and qualitative - of curricula and qualifications they offer	• I71: Openness of key performance indicators of the University • I72: Openness of research results • I73: Openness indicators accreditation University Online • I74: Openness of University rating indicators at the state level

Tab.1: Summary of the European Standards and Guidelines for Internal Quality Assurance in Higher Education

Analyzing the European standards of higher education and the impact of macro trends in the educational system and its transformation can hypothesize about the need for quality content, component of the educational environment of the University, which includes electronic components. Consistency and integrity of its allowing modern university to reach the performance level of European standards.

The results of analysis of international experience show key indicators measuring tools of internal quality standards of modern university education:

1) University website
2) Structural units website
3) Teacher's ranking website
4) Website of electronic teacher's portfolio
5) Website for advanced distance teachers learning
6) Institutional repository
7) Electronic library resources
8) Wiki-portal
9) Educational portal LMS based on MOODLE
10) Specials sections in LMS: e-dean, e-journal, means to assess learning activities of students
11) A resource for assessing the quality of training content (external experts and employers)
12) A resource for analyzing the results of questioning of students
13) A resource with information about implementation of ISO 9001

Due to the transformation of education in the new environment and market requirements to prepare competitive specialists, traditional role of the teacher (broadcasting and reproduction of training materials) is replaced by a number of new roles. The modern teacher is able to select and use electronic resources for student learning; organize cooperation and communication between the participants of the educational process; design, electronic resources and electronic educational environment to be a facilitator and an assistant for students well understood and taken into account in the learning process of their needs and characteristics, cognitive learning styles, new services and tools for effective collaboration, communication, possess the skills 21st century. And therefore is qualitatively change the educational environment of the modern university.

In view of the above it can be argued that the development component of the educational environment in accordance with the requirements of quality and transparency, the use of specific indicators and tools to measure allows university to reach the level of European standards of higher education.

Monitoring of internal quality assurance

The term "monitoring" [14], we understand as the constant monitoring of certain process to determine its compliance with the desired result or starting bid - monitoring, assessment and prediction. To determine the internal quality assurance we were based on the following provisions:

- Monitoring is implemented through a set of methods and clearly established procedures. In contrast to controls, which each year is aimed at new sites, monitoring is aimed at those same objects and periodically repeated.
- In contrast to the conventional understanding of the control of education is a form of monitoring, collection, storage, processing and dissemination of data, providing continuous surveillance of their dynamics.
- Monitoring is not expertise. Examination has mechanisms for deeper and more detailed analysis of the research object.

Monitoring described in this article was conducted at the Borys Grinchenko Kyiv University during June - September 2014 questionnaires developed by the international project IRNet (29, 32).

Target group of respondents – teachers. Monitoring tool - an anonymous online survey.

The questionnaire consisted of six parts (units):

- Determining the level of awareness of the policy establishment and assurance procedures.
- Confirmation (not confirmed) form of review of curricula; use of modern ICT in the classroom.
- Determining the level of formation of e-learning environment of institution
- Monitoring the implementation of distance learning for students

- Determining the level of involvement of students in evaluating the quality of educational services
- Determining the level of formation of citizenship resident knowledge society.

Here is the summary of the results.

1st set of questions. Determining the level of awareness of the policy establishment and assurance procedures.

51% confirmed their awareness of the presence of the University of Documents regulating the activities of teachers in the use of electronic technology and distance learning. 41% were neither confirm nor deny the presence of these documents.

65% are familiar with the contents of the University regulations governing activities in the field of distance learning.

64% are familiar with the procedures for assessing the University as electronic resources and distance learning resources created by teachers. 95% of acquainted data procedures could name specific criteria for assessing the quality of electronic resources and distance learning resources created by teachers.

63% are familiar with the procedures for using public resources.

45% are not familiar with the procedure motivate teachers to create open educational resources.

Summing up the first block we can note the overwhelming awareness of teachers of institutions policies and procedures of quality assurance in the context of the use of ICT.

2nd set of questions. Confirmation (not confirmed) review procedure curricula; use of modern ICT in the classroom.

Only 18% of teachers believe in controlling and monitoring the educational part of school level and efficiency of teacher created e-learning resources. 97% of the number of knowledgeable called specific performance control and monitoring, which analyzes the use of these resources. At the same time, 73% were not aware of the results of this monitoring (promotion, monitoring results, recommendations for monitoring results). 52% of the respondents were unable to neither confirm nor deny the existence of this control.

95% confirmed the establishment and functioning of the university established electronic resources (repositories, electronic research and teaching journals, wikis portals open courses, etc.).

57% confirmed acceptance at the facility level corporate standards of ICT competence of teachers. 52% of all teachers are familiar with the structure of the standards and criteria of assessment.

85% reported active participation of students in quality assessment procedure established open electronic resources and quality control of education.

Consequently, the vast majority of teachers use modern ICT in their work; aware of their role and importance in the learning process. At the same time, most teachers are not familiar with the procedure of monitoring the use of modern ICT in their work.

3rd set of questions. Determining the level of formation of e-learning environment of institution.

95% of respondents confirmed the existence of the University e-learning system LMS Moodle and are aware with its structure. At the same time the level of student use of the system in the opinion of teachers is only 60%.

57% are not familiar with the system of motivation of teachers in the development of e-education space facility. 95% believe that there is no financial motivation.

38% said students contribute actively to the development of e-education space facility.

Generalizing the answers to this set of questions can be noted that almost all the teachers involved in the formation of electronic educational institution environment, although much of unmotivated by such activities. Some teachers actively involve students in the process of filling the electronic learning environment.

4th set of questions. Monitoring of the implementation of distance learning for students.

30% are aware of the existence of an internal ranking of Webometrics the University. 62% aware of its existence.

Only 13% believe in the existence of regulations evaluation of internal ranking of Webometrics for teachers. 75% believe that such documents may exist.

79% of respondents gave an affirmative response to the use of the institution of anti-plagiarism system to check students' scientific works.

At the same time, 85% did not have any tools use the name of the institution to monitor and discuss the quality of distance education.

Thus, all teachers are aware of the need for the use of distance learning, but are not aware of the need of internal ranking of Webometrics.

5th set of questions. Determining the level of involvement of students in evaluating the quality of educational services.

39% of teachers believe in setting database curricula for all subjects.

Only 44% are aware and 43% aware of the existence of a database with information about students. At the same time, 59% are familiar and 31% aware of the existence of a database with information on teachers.

26% of teachers believe in the existence of the institution of tools implementing individual learning paths of students. 54% believe that perhaps these tools implemented in the institution.

84% of respondents claim on existing social interaction between teachers, 84% - between students and 90% between teachers and students, 82% between faculty and students of the institution and other institutions.

44% believe that students enjoy using e-learning courses. 23% believe in the need to use traditional forms and methods.

75% of teachers believe that students use e-learning resources only to perform required tasks with the online versions of courses; 28% - to implement their own learning paths and 62% believe that students use e-learning courses fragmentary.

59% believe that the educational initiative on the use of e-learning resources reveal only some students.

59% of teachers believe that e-learning environment requires school improvement.

The existence of specific courses of training confirmed 87%.

Thus, some teachers continue to follow traditional forms of teaching, aware of the need to use e-Learning space. We can speculate that having every opportunity to improve their own ICT skills of teachers are still slow to implement distance learning because of missing motivation system, or by reason of ignorance of the existence of such a system.

6th set of questions. Determining the level of formation of citizenship resident knowledge society.

69% of respondents recognized Russia as a country they know best. Next in the ranking is Poland, then the Netherlands, Australia and Slovakia. Comfortable level of communication in the selected country noted as a very high 51% (understanding of language and the ability to maintain a conversation). 46% reported having a high level of establishing business contacts. Only 26% reported a high level of knowledge of the culture of the chosen country. At the same time, 43% reported a high level of cultural knowledge and 23% of religious differences between Ukraine and Selected Countries.

34% consider themselves a citizen of the world, 39% of the inhabitants of the continent, 84% of its people, 62% - of the region.

For information about other countries and cultures teachers receive from my own experience - 80% of educational institutions - 39% Media - 67% Internet - 90%.

16% believe that the University creates conditions for the development of intercultural competence, 28% answered that question “probably yes”. 87% believe that in the near future they will develop intercultural competence; 90% reported both forms and methods of development that are implemented in the institution.

72% agree with the statement that globalization and standardization of the learning environment of the system of formal education is a positive trend in the world of higher education; 20% - think negative. At the same time, 67% agree with the statement that globalization and standardization of the learning environment of the system of formal education is a positive development of the national system of higher education.

66% support the policy of e-learning at the state level and 56% at the outset of the absence of such policies at the state level at the time of the survey.

Results of the survey on the block indicate a level of development in teacher’s citizenship resident knowledge society. The majority considers the impact of globalization on education a good thing. Teachers are aware of the need for public policies on e-learning.

Analysis of the European Standards and Guidelines for Quality Assurance in Higher Education [11] noted that the main activities of the modern university teacher should focus on creating high quality content and use learning environment. The results of our survey confirm the relationship between the quality of e-learning space created by university and levels of ICT competence of the teacher.

Model of corporate standard of ICT competence of teaching staff

Information and communication competence is known as proven ability to understand individual autonomy and responsibility in practice ICT to meet their individual needs and solving socially important, in particular professional tasks in a particular subject area or field of activity.

Framework structure of ICT competence of teachers described in the recommendations of UNESCO, which includes six modules: understanding the role of ICT in education, curriculum and assessment, pedagogical practices, hardware and software ICT, organization and learning management, professional development, considered as the basis for creating an appropriate model for high school teachers.

Another document, which must be taken into account in the establishment of this model, is the European ICT competency framework 2.0 (2011).

Framework of ICT competences (The European e-Competence Framework, then e-CF) is a framework describing ICT competencies to be used in business organizations and educational institutions in determining the areas of training professionals to the modern labor market and the content of their training. e-CF serves as a tool for international schools in the following tasks:

- Development, implementation and management of IT projects and processes in the school;
- The use of ICT;
- Decision-making, development strategies;
- Prediction of new learning scenarios and more.

The structure of the ICT competences 2.0 framework consists of 4 descriptors that reflect the different requirements for management staff, and is in addition to the management of the duties of employees (see. Fig. 1).

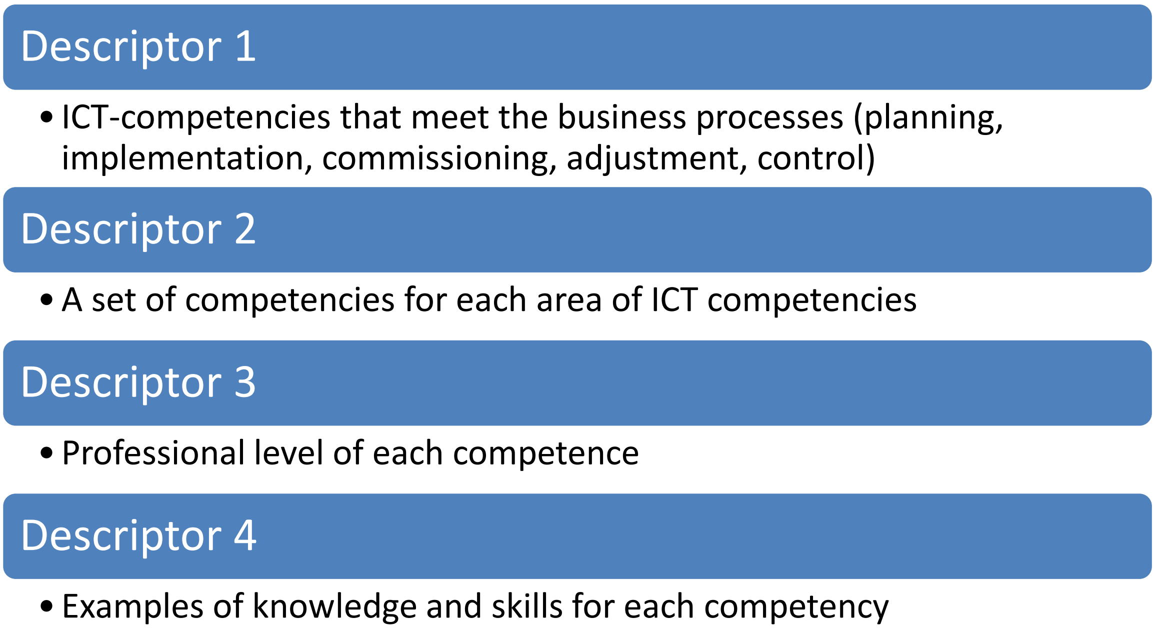

Fig. 1: Structure of the ICT competence 2.0 framework

The model of corporate standard of ICT competence of teaching staff of the modern university is based on the relevant recommendations of UNESCO and the European frame ICT competence 2.0 into account the peculiarities of scientific-pedagogical employee in the context of the Standards and Guidelines for Quality Assurance in the European Higher Education Area, namely: understanding of the role of ICT in education and their use of ICT use, educational activities, research activities and training.

During the determination of the formation level of ICT competence of teachers is expedient to take as a basis the standard quality of higher education in the European and according to them to determine the appropriate tools and evaluation criteria. In addition to the basic documents of this issue include of ISO 9000: 2007 and ENQA (European Association for Quality Assurance in Higher Education), which contain commonly required or needs or expectation.

The standard ENQA special emphasis calls on the following indicators: teaching (learning process, teaching activities); scientific and teaching staff; educational programs; material base, information and educational environment; students (students, prospective students); educational management; research.

Considering above and the results of a survey of teachers of Borys Grinchenko Kyiv University, the model of corporate standard of ICT competence can be presented according to the main types of university lecturer, highlighting three levels: basic, professional and advanced (Table. 2).

Activity	**Base level**	**Advanced level**	**Professional level**
Understanding the role of ICT in education and their use	Basic knowledge	Participation in group initiatives of regional and national levels	Development strategy of informatization of education at the University
ICT	Basic tools	Creating e-learning courses	Continuous update of e-portfolio
Educational work	Application of knowledge and skills	System using of ICT	Creation and support of open educational resources
Scientific activities	Using ICT to find information	Presentation of the scientific community the results of their own research activities through the use of ICT	Coordination and participation in international research projects
Advanced training	Access to resources for professional development	Creating an own e-portfolio	Participation in MOOC (massive open online courses)

Tab. 2: Model of corporate standard of ICT competence for the teaching staff

According to the model developed by us, there are following measurement tools of the level of formation of the ICT competence Standard of teachers at university:

	Base level	**Advanced level**	**Professional level**
Understanding the role of ICT in education and their use			
Measurement tools	1. Online survey to determine the level of awareness of teachers about the availability of documents on education policy at the University or the State and their role in the activities of the university. 2. Participation in seminars (full-time or remote) on educational policy of the University	1. Survey of students for use in the profession of innovative educational policy. 2. The survey of teachers in understanding ways to use innovation in the profession of education policy. 3. Survey of students to determine the role of ICT in education and identify requests students to enrich the e-university environment. 4.Teacher's e-portfolio: availability of data on participation in some group of educational initiatives	1. E-portfolio: availability of information on participation in the group to create new educational development, a strategy for ICT and their use.
ICT			
Measurement tools	1. Tests for independent verification of levels of basic tools (created by the University, IT-Academy).	1.Certified electronic educational course, which is a necessary condition for the use of complex ICT tools. 3. Teaching materials are based on the use of e-tools	1. Usage of Wiki portal. 2. Own blog of the teacher. 3. Usage of social networks for education.

	2. Some components of e-learning courses (electronic educational course)		4. Teacher's e-portfolio.
Educational Activities			
Measurement tools	1.Survey of students about the quality of fragmented use of ICT. 2.E-testing students' educational achievements. 3.Availability of electronic course in LMS Moodle. 4.Questioning teachers in understanding the effectiveness the use of ICT in practice.	1.Statistics of usage by students of electronic course, placed on LMS Moodle. 2.Links in electronic course on Institutional repository resources. 3.Links on open e-resources. 4.Links on open learning courses (MOOC). 5.E-science publications. 6. Survey of students on teacher satisfaction with the proposed e-resources. 7.Evaluation of training programs: a list of recommended resources. 8.Availability of certified electronic courses on each disciplines that teacher teaches. 9.Assessment of systematic use of electronic course resources: reports on e-dean and electronic gradebook of specific electronic course. 10.Availability on the Wiki portal annotations to certified electronic course. 11.Assessment of systematic use of resources in the university environment	1.Creation an open electronic courses (MOOC) and statistics of their members. 2.Organization of email communication and collaboration (including educational projects) in soc. networks and on the basis of virtual communication (skype, video conferences, webinars, etc.). 3. Joint projects on the Wiki portal. 4. Teacher's e-portfolio. 5.The use of ICT for administration of the educational process
Scientific activities			
Measurement tools	1.Survey for teachers awareness on the use of scientific communication: repositories, scientometric databases, e-libraries, e-journals, as well as opportunities and	1. Number of international publications. 2. Number of appearances at international conferences	1.Participation in Intercollegiate and international research projects. 2. Teacher's e-portfolio. 3.Number of joint international publications with scientists from other universities.

	participate in online conferences. 2.Number of publication in Institutional repository. 3.Citations index in Google Scholar.		4.Citations index in international scientometric databases. 5.Organization and conduct online conferences, seminars.
Advanced teachers training			
Measurement tools	The certificate of training for ICT	1.E-portfolio. 2.Participation in distance training courses in Ukraine. 3.List of graduated non-formal learning.	1.E-portfolio. 2.The list of graduated open professional online learning courses (MOOC). 3.Training for colleagues on the use of ICT. 5.Online consultations, conducting webinars out of the experience.

Tab. 3: Tools to measure the level of educators' formation in the ICT competence standards.

Conclusion

The impact of technology [2] on the occurrence of macro-trends and reform of higher education in Ukraine supports the hypothesis urgent development and implementation of standards for information and communication competence of teaching staff in terms of European integration processes of modern higher education.

Due to the transformation of education in the new environment and market requirements to prepare competitive specialists traditional role of the teacher (broadcasting and reproduction of training materials) is replaced by a number of new roles. The modern teacher is able to select and use electronic resources for student learning; organize cooperation and communication between the participants of the educational process; design electronic resources and electronic educational environment; to be a facilitator and an assistant for students; well understood and taken into account in the learning process of their needs and characteristics, cognitive learning styles, new services and tools for effective collaboration, communication, possess the skills of 21st century. And therefore must meet a certain level of ICT competence of teachers.

Terms of successful formation of the ICT competence of teaching staff universities include:

- Development and adoption of corporate standards of teaching staff of the University, including information and communication competence. Should be set the same standards, criteria, indicators and measurement tools of their formation.
- Implementation of training of teaching staff in the field of information and communication technology competence and their effective use in the classroom.

- The creation and ongoing development of personal educational environments of students and teachers.

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IPAD IN EDUCATION: TEACHER'S EFFECTIVE TOOL IN FRONTAL EDUCATION

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In recent years, the ICT market has seen a massive shift of users toward mobile devices. While a few years ago a classic computer was the only work device, today it can be easily replaced with a portable laptop. We are now experiencing a similar situation, a shift of users toward the even more mobile devices – tablets. Teacher's work must reflect the trend. Does a tablet offer anything new and different to the teacher? In my paper I focus on the possibilities of the use of the iPad tablet with the iOS operating system from the point of view of the teacher.

Since the iPad is designed as a personal device, its use in school is divided into parts – as a teacher's tool and as a student's direct tool (which is commonly referred to as the 1:1 model). Moreover, many schools use the mobile classroom model with shared iPads (like computers in the computer classroom). In my paper I focus on the use of the iPad as a teacher's tool for it is a teacher's personal iPad that is often the first such device in the entire school.

One of the most frequently used methods of education is frontal (collective) education. Frontal education is based on the teacher working collectively with all students in the classroom in one form and with the same content of activities. As a result, the classroom is arranged accordingly (Průcha, Walterová, Mareš 2001). Frontal education consists not only of the teacher's instruction but also of the tasks assigned and managed by the teacher, collective revision of homework or class work tasks, discussion between the teacher and students, the summary of the curriculum, providing feedback and evaluation of students. Because of negative connotations, the term frontal education is sometimes replaced by the term direct education.

According to the CSI (Czech School Inspectorate) annual report, in the 2011/12 academic year teachers used ICT in education in 27-40% of classes (according to the type of school). On the other hand, ICT was actively used by students in only 4.1-6.3% of classes. The results show that ICT tools are used mainly by the teacher as a presentation tool. We can assume that a classroom with a projector (interactive board) and one central point with a computer or laptop is a typical model of the use of a computer as a presentation tool. The teacher operates the computer either from the central point or uses auxiliary tools such as a presenter or another type of remote control. However, this model can be easily changed through the use of a touchscreen device. A touchscreen device enables the teacher to move around the classroom while a wireless network secures a permanent connection to a projector and the Internet. Moreover, a touchscreen device makes it possible to move a presentation point in front of the student. In the original model, on the other hand, the student had to stand in front of the classroom.

A tablet makes it possible to change the established way of frontal education. Because of the possibility to move a presentation point to any place in the classroom, every student can be immediately actively involved in the education process.

Application

In contrast to similar devices or laptops, an enormous number of education applications for iPad are being developed. There are more than 90 thousand applications from all areas of education. Thanks to those applications the iPad can be a geography atlas, the periodic table of elements, a 3D model of human body, an interactive board or a graphic calculator. Those applications are often free or cheap. The popularity of iPads gave rise to a large number of Internet forums where teachers share their experience and tips on interesting applications.

As far as developers are concerned, the iOS operating system is a closed system. It means that only applications that have been tested and approved by a third party (Apple, Inc. – the iPad designer) can be run on the iPad. Even though this limitation appears to be a problem, the common user actually benefits from it as it reduces the risk of being attacked by a virus or malware. As a result, the teacher does not have to worry about the technical aspects of the device and can use the iPad as a work device with tested and approved applications.

The installation of applications can be carried out from one place only – the AppStore. No installation packages need to be downloaded and no installation location needs to be set. As a result, the installation can be carried out even by a computer layman.

Connecting the iPad to a screen

In order to make a full use of the iPad in the classroom, it is necessary to connect it to a projector. This can be done through a simple VGA adapter or through a wireless transfer of the picture using the AirPlay technology. It is the wireless transfer of the picture that teachers appreciate the most. It enables the teacher to move around the classroom so they no longer have to be “chained” to one point. The iPad can be placed in front of any student who can then work as if they were at the blackboard. It is not important where in the classroom the computer is as the projection can be made from anywhere.

In order to obtain picture reception, the classroom needs to have Apple TV which needs to be connected to a wireless network. The wireless network is necessary for the iPad to work properly. Both devices, the iPad and Apple TV, need to be connected to the wireless network. Apple TV is connected to the projector through the HDMI interface which transmits both picture and sound. Unfortunately, the older projectors used in our schools do not have the HDMI interface. However, this problem can be solved through a simple HDMI to VGA reduction.

Frontal education support

Frontal education is often considered one of the least effective methods of education. Its low effectiveness is caused by the low active participation of students in classes and the prevailing activity of the teacher. As far as at the typical frontal education class from the point of view of the possible use of the tablet is concerned, there are several crucial ways to improve the effectiveness of frontal education.

A presentation is a commonly used tool for the support of frontal education. In the common model it means the use of a computer and a projector. The teacher usually sits at the computer and in so doing they lose natural contact with their students. As a result, communication with all students a large classroom may become problematic. If a tablet with a wireless connection to a projector is used for a presentation, the teacher can move around the classroom and actively talk with students in their own personal space. As a result, students need to pay attention to the teacher all the time and be prepared for their additional questions.

A tablet's built-in camera is another support tool. Together with a wireless projection a tablet can be used as a portable visualizer. A chemical experiment from a different part of the classroom or students working in their workspace can be displayed on the projection screen. If an experiment is a part of the class, it can be effectively presented to students. Moreover, the iPad captures an instant video recording and the recording can immediately be posted on popular social networks. Therefore, the student can revise the experiment during their home preparation.

Mobility is an important feature of the iPad. As far as frontal education is concerned, mobility improves students' active participation in the class. If we need to receive feedback, students have to be actively involved in the class, which can be achieved by asking them additional questions. Through the use of a proper application the tablet can be placed in front of students who do not have to only verbally answer but can also work with the tablet with their answer being displayed on the projection screen. This also increases the participation of all students. Moreover, the tablet's mobility makes it possible for the teacher to ask the student a question without their having to move to the blackboard or the central computer.

Examples of applications for the support of frontal education

Microsoft PowerPoint is one of the classic presentation programs. Its free version enables the use of the existing iPad applications. Another application is a non-linear presentation program Prezi, which has its own online storage service. Moreover, there is an application designed specifically for the iPad – Keynote.

Another group of applications makes the iPad screen an interactive area that is transferred to the projector. As a result, the iPad behaves like a mobile interactive board. Examples of such applications are Explain Everything, Show Me or Stage Whiteboard. All of the applications can capture a video recording.

Applications for the evaluation of feedback are often linked to web applications. This allows students in frontal education to participate using their own devices so the teacher's tablet is used for the evaluation of answers. The most frequently used applications are Socrates and Nearpod.

Conclusion

Mobile touchscreen devices bring new elements to the work of teachers which can help make the classic frontal model of education more effective. Connecting the tablet with the projector enables the teacher to move around the classroom and improves the teacher's contact with their students. The use of proper applications enables the addition of practical examples and experiments to frontal education. Web applications help the teacher to receive feedback which they can immediately evaluate in the class.

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