E-learning in mathematics

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***Abstract*—The problems in the e-learning course market (for example their low sales compared to mobile applications) show that besides the development of new technologies, it is necessary to also pay attention to other factors that affect the creation of meaningful courses. These factors are the content of said courses, as well as their real applications as related to their didactic and educational aims. Furthermore, attention has to be paid to the administration and maintenance of courses and the training of educators in their proper use. In this article we aim to show the risks of over-dependence on ICT technologies in the teaching of mathematics, and suggest who should be preparing meaningful e-learning courses.**

I. Introduction

Fifteen years ago it was hard to imagine all that would be achievable using ICT technologies in the year 2011. The accessibility of computers and the internet has increased exponentially. There were some who owned computers, or mobile phones, and some teachers used ICT technologies. Today there are few in Slovakia who do not own a mobile phone or computer, and yet we know no teachers, parents, or students who would purchase an e-learning math course with their own money.

Herein lies the essential problem of the development of technical support for teaching: e-learning courses are created by those who want to sell them, and not those who want to use them to learn. The incorrect motivation then leads to the creation of mathematics courses that mirror the ideas of software developers. To the layman the course appears as mathematics, however it does not lead to the development of the logical thinking of children or the acquiring of other math skills such as the ability to make arguments, propose an experiment, make analogies, systematize knowledge, think critically about conclusions, pose the right questions, and create relationships and connections between knowledge. Instead, mathematics is presented in a "rounded-out", finite form and structure. When building concepts and knowledge, the progression and the structure of their development are significantly different. This fact is ignored. Mathematics is "demonstrated", presented and developed through external symbols: elegant presentation, schooled actor voices (who know nothing of what they speak of, and intonate in discord with the logic of the content) etc. Some statements are often even erroneous and incorrect, to the point where it seems that we are presented merely with the viewpoint of the authors of the software, who understand mathematics only formally and superficially.

In this article we will attempt to explore why e-learning lessons often do not support, and sometimes even hinder the teaching of mathematics. We will introduce certain mechanisms of the teaching and learning of this scientific discipline, and the risks that come with ignoring them. We will also propose some principles that could help in creating useful e-learning aids for teaching mathematics. We base these on a constructivist approach towards teaching mathematics. From the rich literature describing and illustrating the approach, we name for example publications [1], [2], [3]. This approach is certainly more difficult and complicated to integrate into e-learning applications than its opposite, called also the transmissive approach. There the chief task of the educator, and the education itself, is the direct transmission of the required, defined area and structure of knowledge "from the mind of the teacher into the mind of the pupil". The reality that this approach is much more acceptable, even optimal, for e-learning is a further possible main problem.

II. Multimedia Perfection And The Creation of Mathematical Knowledge

Mathematical growth and development occurs, even in the case of reaction to regular schooling, firstly in the mind of the student. The optimal method is the creation and building of concepts on the basis of the child's own activities, experiences, and discoveries. It should be, in a realistic magnitude, experienced by every elementary school student. Mathematically gifted and talented children of this age are in our experience able to, under expert guidance, independently build and create the majority of the required mathematical knowledge. However, a time commitment beyond usual classroom education is required.

The time requirements therefore lead to the students' acquiring the majority of material as external, passed on information. However, for quality education it is necessary for the mathematical knowledge to create a so-called cognitive map: it must interconnect both with itself and with the life experiences of the student. Otherwise we build pointless, even harmful, formal knowledge. The newly acquired knowledge needs to be made one's own, the student must process and confront it with his or her past knowledge. The intensity and quality of this process determines the success of the education.

One of the risks of mathematical e-learning, created by its great multimedia possibilites, is the blocking and suppression of these activities of the student. Psychology gives us a key piece of knowledge: the more senses (and potentially emotions) we engage in order to receive knowledge, the smaller the magnitude of our active mental processing, and conversely the larger the magnitude of our non-critical acceptance, without a corresponding placement within existing structures of experience and knowledge. Imagine, for example, an

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action or romantic scene first as a novel, comic book, black-and-white film and finally as a slick modern movie. Try to compare the methods and results of the mental activity used in processing these inputs.

If our goal is an excellent theatre performance, a powerful film, or an effective commercial, if we want to surprise or shock, then the suppression of the critical thinking and doubting of the viewer is warranted. However, we seriously doubt this is the case in the teaching of mathematics. A polished, multimedia form of presenting and transmitting mathematical knowledge has, based on the described mechanism, and unpleasant but natural tendency to lead to the building of formal, unpersonalized knowledge structures. From the point of view of students who will not significantly utilize mathematics in their future lives, this form of learning is useless. For students who may direct their further studies towards natural sciences and technical fields, it is even harmful. It excludes important learning devices such as

- incorrect formulations and their specification,
- performing unnecessary experiments, and inventing better ones,
- presenting one's own notions and their defense,
- the right to make errors, and the subsequent search for methods by which to reveal and remove said error,
- debating and utilizing analogies.

The listed skills are much more important for doing mathematics, and its utilization in other fields, than repeating definitions and propositions that mean nothing to the students, which they cannot connect to the objects of the real world or to other mathematical concepts.

III. Educational Atmosphere and The Role of the Instructor

. There are two key factors in the quality of mathematical education. The first is the mood, atmosphere of the lessons. This can motivate the students and at the same time harmonize and unify the processes and methods of working of the class. It should be, depending on the circumstances, inspirational, creative, and disciplined. The second factor is the personality of the instructor, his contact and relationship with the students, ability to motivate them, direct their work and discussion.

Much practical experience from classes supported by computers goes against these principles. The teacher devotes a significant amount of energy, time, and attention towards preparing and the subsequent technical execution of the lesson. The actual interaction with students takes the form of mediation, often in the form of prepared methods and presentations deviating from which is often technically not possible or supported. Excessive questions from the students are disruptive and complicate the prepared flow of the lesson. The instructor largely takes on the role of a well trained operator, and much of the opportunity for direct work with the class is lost. The instructor loses much of his ability to observe the overall situation within the class, to create and direct a learning atmosphere, to react directly to the cues and responses of the students. The great effort required to prepare a lesson using ICT technologies leads to an unwillingness to significantly change its contents or direction, even if the situation demands it.

Problems can also arise in the overall mood of the learning process. A classroom equipped with computers is a significantly limiting environment. Working with a PC, an activity not yet quite automated in elementary school students, is distracting, wasting a lot of the attention and energy of both the students and the teacher. Even simply varying levels of competence with a mouse and keyboard can disrupt the progress of the class and decrease attention, especially since the visual attention of the students is focused on the screen. From personal experience we certainly recognize the feeling of concentration and suppression of other stimuli from the moment we place our hands on the keyboard and begin staring at the screen. In this situation it is extremely difficult to impossible for the teacher to adjust the atmosphere and capture the coordinated attention of all the students, to switch between lecturing, discussion, and individual work. Never even mind solving personal problems, cultivating the verbal expression of the students, publicly praising a weaker student for an original solution, directing a bright student who is ridiculing a weaker solution, or praising a student for helping a peer or his courage in contradicting the teacher and pointing out an error.

We have extensive experience with teaching mathematical subjects at a post-secondary level in computer laboratories. We are convinced that teaching mathematics to future computer scientists in the context of their main focus makes sense. However, even for those students it still holds true that the student should only use a computer if it is absolutely necessary. Otherwise, the computers remain off. Additionally, the teacher has an instrument with which to globally control all the screens in the room, or potentially disable the keyboards. Our experience leads us to believe that meaningful work on a PC is possible only when the students have sufficiently understood the essence of the problem and have an idea about their strategies for solving it. This cannot be provided by a PC, to the contrary a PC can be disruptive and a hindrance.

One of the newest innovations is the interactive electronic chalkboard, which has acquitted itself well as a new type of display apparatus on which it is possible to show prepared presentations. It is difficult to use this technology, however, for creative instruction, where it is necessary to react to new ideas and thoughts and often change the expected lesson plan. Classrooms equipped only with electronic chalkboards were, after gaining teaching experience, quickly supplemented with traditional chalkboards.

By contrast, we have had great experiences with primary school students. Here we used ICT applications whose role was to motivate the students towards solving problems that were at the edge of their abilities, that is difficult for their age group. An example of such an experience is described in the article [6]. It is also possible to use ICT to motivate the tiring practice of arithmetic skills, where besides understanding and memorizing the algorithm it is necessary to practice it. This motivation can take various forms, we have used for example games where the student can only make a move after solving a problem.

Similarly, another motivational tool can be an application that actively maintains the student's ranking in the class based on the number and difficulty of problems solved.

In elementary school, the most important thing for the younger students is motivation and feedback from the teacher. His opinions and attitudes are more important to the formation of the students' personality than any formal evaluation. Experience from intensives for mathematically talented children even tells us that the students appreciate authentic behaviour from the instructor such as annoyance, or anger, much mores so than a professional mask of smiles that does not reflect the instructor's true state. How then must the student view instruction at the push of a button, which is exactly the same for every class and every student.

For older students of elementary schools, the tie to society is equally strong, just instead of the teacher it focuses more on the class and their peers.

The aforementioned reasons are why the instructor needs to understand the needs and abilities of the students, to constantly think about their expression and needs, to improve the pedagogic aspects of the instruction, and not least of all for him to be an expert in the subject and theme being taught. The idea that instead of a teacher a lesson could be delivered via a video with an explanation of the subject matter is not only demeaning towards the teacher, but also simply mistaken. A teacher must be truly weak for a filmed lesson to be better than a real one.

These kinds of lectures are however recorded, and do have a justification. For example the [4] provides excellent lectures, which can be used by students who do not have access to traditional education to supplement their knowledge through distance education.

We consider it meaningful to create e-learning courses that an individual can use to set his own tempo of learning, and are focused mainly on developing skills. These can be, for example, first aid courses, typing courses, driving courses. We consider it counterproductive to use mathematics courses consisting of a video recording of a lecture in class. This kind of instruction spoils not only students, but even the teachers.

IV. Evaluating the Effectiveness of E-Learning

T We are interested to know whether there exists, in our context, a generally known and seriously documented case study where e-learning in mathematics classes led to a better result than comparable instruction using other methods. Very often we are faced with arguments that the form and idea are sound, and it is merely the content that needs to be fine-tuned. Possibly other details: students must be conscientious and responsible, they need to be motivated, schools must be willing to invest into technologies. To our generation, this is reminiscent of other unsuccessful attempts to implement an excellent idea, which thankfully since the year 1989 no longer continue in Slovakia.

We want to believe that there are positive examples. However, thus far we have several opposing experiences. In the year 2007 we heard at this conference a contribution concerning a realized e-course of a university level math subject. During the course of discussion we asked whether the success and effectiveness of the course was measured against a concurrently running standard course, which would be easily done using a final exam. Instead of an answer, we received a counter-question whether we mean to doubt the usefulness of ICT in education. Another, very current, experience shows that verifying the suitability and effectiveness of e-learning products more resembles a well planned marketing opportunity. The "testing" is done on a large group of students, teachers, and schools, however during its course they are motivated and rewarded in a way that damages objectivity. The experience and methods of IT firms easily change testing into a process for creating a strong group of fans and lobbyists. Once again, there is a distinct lack of opportunity to compare against a control group using traditional methods. The basis for evaluation should be comparing the results of students with and without using the product in question. The evaluation should be based on an objective measure, not simply the opinions of selected teachers.

We think that real, honest testing of the success of the methods and products of mathematical e-learning is very important, and should also be in the interest of their creators. This is one of the paths to improving the electronic teaching of more than just mathematics. The current absence, or minimal scope of testing is certainly one of the sources of problems in this area.

At the same time, it is easy to understand why this is the case. The gradual increase in the number of computers in primary and secondary schools creates a large and tempting market. The schools, teachers, students, and their parents represent strong marketing groups, and furthermore the bills are conveniently paid for by the government. Thus it is not surprising that the major players in this field bring forth strong marketing tools, which often drown out and hide honest studies and any potentially unfavourable results.

On the other hand there is the objectively dire state of mathematical education in Slovakia. Taking a broad overview, the quality is unsatisfactory and mathematics is losing both its position and popularity. One of the key reasons is the offset between the breadth of the expected learning outcomes and the actual capabilities of the students, teachers, and schools. (A reduction of this breadth as a part of the current reform is from this point of view a reasonable measure.) Another reason is the wrong direction taken in the preparation of teachers, who are saddled with an overabundance of abstract mathematical knowledge and provided with desperately few real pedagogic tools for handling actual instruction. The consequence is many disappointed teachers, disinterested students, and unhappy parents and wider society.

In this situation, we have a tendency to believe and hope in a "magical" solution, something that ICT technologies currently may seem to offer. If we believe that the main strategy should be to make education more "attractive", then this route seems very promising. However, real solutions lie elsewhere, though quality e-learning can definitely contribute there as well. We must honestly explore both its opportunities as well as limitations, using proper scientific scepticism. That happens to be in conflict with the excitement and expectations stemming from the discovery of a potential happy solution to an unfortunate situation.

The discovery of a universal solution to all educational problems is a well known theme in mathematics, and one

that should be treated with caution. We speak of a worldwide experience from the 1970's, that even thorough testing, comparing, and evaluation of methods of instruction, as well as enthusiasm and agreement of the testing instructors do not guarantee correct conclusions. During this time, under the influence of the success of structuralism, there was a decision to base mathematical instruction from the earliest grades on the concepts of set theory. From a strictly mathematical perspective, these present a unified foundation and starting point. The experiment took place in many countries: from France, to the USA, all the way to the countries of the Eastern Bloc. It was preceded by a pilot program with excellent results. Only in hindsight was it apparent that the enthusiasm of the teachers taking part in the experiment, their desire for new, modern teaching methods utilizing their own creativity, resulted in the results being in favour of the new teaching concepts. The subsequent large-scale implementation in schools was a fiasco, and after a few years the entire reform failed. More so than the testing, the objections raised by a minority, questioning the didactic suitability of the methods almost from the very start, proved to be accurate.

V. DOES E-LEARNING SAVE US WORK AND EXPENSES?

The possibility of saving the work, effort, and energy expended during teaching is often a big temptation of new technologies. If it however becomes their main goal, we invite mistakes and errors.

We would certainly be surprised should physical education be taught in schools by having the students watch a video of a somersault, then having them correct the somersaulting mistakes of an interactive avatar using a computer, and finally writing an exam about the correct way to perform a somersault. (This method would be correct if we were learning *about* physical education, or if we were trying to lead an active gymnast towards a more perfect motion. In the general population, it would however lead to a high risk of injury when attempting an actual somersault.) This would likely be considered nonsense by everyone, as sporting skills must be acquired through individual activity.

There is no reason to believe that mathematics is any less challenging than physical education, and the thought processes of the students can be replaced by a computer. Nevertheless, very seriously intended attempts at precisely this are common today. From experience and the results of PISA testing, we know that students have difficulties with word problems, especially with understanding a more extensive, context-based written problem, and its transformation all the way into the correct calculation leading to obtaining the solution. Our students need to improve and develop this ability. What should we then think of an e-learning product that displays a word problem, reads it, then announces the proper steps for solving it, and finally visually demonstrates them and verbally comments. The procedure furthermore utilizes multimedia tools, so the student cannot replicate it on paper. Instead of commenting, I would like to remind you of the somersault.

The temptation to unburden the student of work, to accelerate the course of instruction and make it more pleasant, is very strong. However, it is very important to carefully consider whether we are truly unburdening the student of activity that unnecessarily hinders him or her from progress towards an important goal. An example can be various computer-aided experiments (statistical, probabilistic, numeric, geometric), where keeping track of parameters and results can be simply a work-intensive burden. We must not however make a mistake and entrust to a computer any activity of a student that is a fundamental part of the learning process, whether it is the practicing of certain routine operations, or conversely the attempt to discover and formulate important properties of prime numbers or polygon diagonals.

What is the situation when it comes to saving work on the teacher's side of things? As an extreme example we can consider opinions such as "*If I record a video of my own lesson, I can then play it back for students in future years and don't even have to show up!"* These kinds of ideas are not only a degradation of e-learning, but of education in general. On the other hand, we must admit that some teachers might obtain better results with students should they replace themselves with a video. In our own experiences with utilizing e-learning, the majority of cases brought us more work, more effort, and more energy required while teaching. The first step is of course the necessity to acquaint oneself with the utilized tools, and then monitoring and managing their updates. We have already mentioned the heightened demands on the teacher's preparation, but this is also the case during the course of instruction. ICT technologies allow for much more convenient methods of submitting, grading, and checking of student assignments. Instead of several submitted assignments per semester, we now find ourselves checking dozens every week. The option to electronically publish study and work materials is convenient, however it leads to the need for their timely creation, continuous adjustments according to the current progress of instruction etc. We could continue with similar examples for quite some time.

At first glance from this point of view, the utilization of e-learning seems counterproductive. However, this passage is neither a lament nor a complaint. The extra work necessary has returned to us where it matters: in the form of smarter, more educated, and happier students. In summary, the main goal of e-learning tools should not be saving the teacher work, but instead to offer new tools for improving the learning process.

Besides considerations about saving work for students and teachers, there is another matter to consider: that of financial expenses. It is obvious that computers are more expensive than chalk and chalkboards, but usually we are assured that the costs are acceptable and proportional to the benefits. We discussed the measuring of said benefits in the preceding section. Here we would like to warn that it is necessary to be aware of all the expenses related to the operation of e-learning classrooms and equipment. The initial expenses are often covered by a project or program. Each device however represents a budgeting load that is hard to then get rid of. The majority of technology today is obsolete within a matter of just a few years and needs to be fully replaced. Another load is the cost of operation and repairs. That is why investing in equipment is a long-term financial commitment. Hardware innovation also brings with it the need for continual learning software innovation. Special products with a multimedia and interactive focus are very sensitive to

changes in peripherals, input devices, operating systems etc.

These arguments relate not only to schools, but also the households of the students. This much is suggested through various ideas of replacing textbooks, workbooks, and homework with accessing learning programs and portals from home. Furthermore, if we do not establish a parent's responsibility to purchase a computer by law, we create an intriguing customer - the government - who can do it for everyone. In a post-secondary environment, these kinds of intentions have already appeared. Also taken into account must be the opinion of a parent from a discussion about a quality, functioning learning software: "*It's a nice program, but my son sits at his PC after school more than enough as it is. I don't want him to do this at school and for school as well, when there are lots of alternative learning tools and methods."* Not every parent believes that just because something is done on a computer at school it is necessarily better, or better for their kids.

necessarily better, or better for their kids.

VI. Does E-Learning Help Mathematics?

Definitely yes, but it must be used in moderation, avoiding mistakes and staying aware of other considerations. ICT is irreplaceable mainly in making routine repetitive actions easier: transmitting organisational information to the students (due dates, instructions, announcements), ongoing and flexible publishing of study materials, directing the submission of homework, formalizing and de-personalizing exams (the teacher is an ally of the student, preparing him for the test, which can then thanks to technology be administered objectively), announcing test results, student discussion about problems, and distance education for those unable to attend in person.

In a truly bad educational situation, it can even be an improvement to show recorded math lectures. However, we feel that this is advancement in the wrong direction. If we save the starving by feeding them a diet of fast-food, we solve one problem only to soon replace it with others.

When teaching, it is important to take into account that we are working with different target groups. For some students mathematics will only be necessary for everyday life, for others it is an aid (sociology, medicine), a working tool (computer science, engineering, meteorology), and only for a select few: their profession and main area of interest (mathematics, physics). The approach for each of these differs, affecting the content and breadth of instruction. Of course, at the elementary school level we cannot yet determine which category a student will fall into. Therefore it is a problem with non-trivial solutions.

Well taught mathematics can also develop more universal, metacognitive aims. One of these is to create and cultivate the capability and methods of causal, logical thinking. Another, equally important, is to gain the experience of creative and original thinking, to experience the joy of an intellectual discovery. Our educational system should be required to provide these experiences for its students as a part of the schooling process. (Just as it should provide encounters with quality literature and music, foreign languages and culture, and the mastering and cultivating of certain physical activities.)

For these goals, mathematics provides sufficient, and compared to other subjects almost optimal, options and conditions.

Education based on the presentation of facts and subsequent training of standard solutions lead to mechanical repetition of learned procedures, the memorizing of formal knowledge, an inability to apply knowledge, connect and modify gained knowledge and abilities, and negative attitudes towards mathematics, which already manifest today in the decreased interest and quality of students interested in the natural sciences and technical disciplines.

VII. What Should the Creation of Useful Educational Software Look Like?

First of all, we should take advantage of the experience gained from already commenced educational reforms in countries where students' results have improved in international PISA testing. In the article [5], it is stated that the biggest improvement was seen among students from those countries where education was decentralized. For e-learning, this means that we shouldn't buy the same product for all schools, but instead give the teacher a choice. We can have a central repository of materials, which can then be selected from. In this database, teachers can access individual materials sorted based on the government educational aims that they can fulfill (sorted by difficulty, knowledge level, ability, and approach).

Optimal preparation of educational e-objects would consist of a teacher giving the requirements for a particular piece of software from his or her experience. A programmer would then create such an object. Of course a teacher may not always be aware of all that it is possible to program, or develop. The ideas of programmers can be interesting and the teacher may not be able to imagine all that it is possible to do. Therefore a mutual collaboration of teachers and developers should continue after the completion of the product. Modifications should be performed even after testing the product in classrooms.

Each software offered should also have a simple, reasonably priced version with intuitive controls. Expansions and new versions should be compatible with previous versions. Software for schools should be prepared by university students as a part of the completion of their studies and enthusiasts who understand education, not giant companies whose goal is to maximize profit. If we can ask teachers to teach for meager salaries, why can't we find developers also willing to consider their work a calling as opposed to simply a profitable endeavour.

It is becoming apparent that products created by teachers based on their experience together with programming enthusiasts are much more usable for teaching than professional products created with the goal of making money. In fact, these professional products often battle scholarly and didactic deficiencies, which are compensated for with investments into advertising and marketing. Students, and often even teachers are left defenseless against the lack of quality in e-learning. It is therefore necessary to support institutions that have the quality of education on their agenda, so that they make correct decisions in the direction and funding of the development of educational ICT technologies.

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REFERENCES

[1] M. Hejný at al., "Creative teaching in mathematics", Charles University in Prague, Czech Republic, Kassel University, Germany, Aristotle University, Thessaloniki, Greece, University of Derby, United Kingdom, vydala Univerzita Karlova v Prahe, 2006, ISBN 80-7290-280-6

[2] M. Hejný, F. Kuřina, Dítě, škola a matematika (Konstruktivistické přístupy k vyučování)}, Praha, Portál 2001, ISBN 80-7178-581-4

[3] V. Hejný, "Psychológia pre pedagóga v terrene", the estate archive, unpublished

[4] http://www.khanacademy.org

[5] "Jak vychovat nejchytřejší děti", http://eduin.cz/titulka/jak-vychovat-nejchytrejsi-deti/ preklad z The Economist (22.9.2011)

[6] K.Bachratá, H.Bachratý, **"**The software for teaching in groups", *ICETA 2010,* : Stará Lesná, Slovakia. - Košice: Elfa, 2010. - ISBN 978-80-8086-166-7. – pp. 193-197, October 2010, [8th international conference on emerging e-learning technologies and applications]

Implementation of Method for Dynamic Noise Visualisation into Educational Process

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***Abstract*—Dynamic noise visualization represents ideal tool for clear and concise presentation of events not recordable with human eye and its implementation into educational process. Visualization is the right tool for students, that allows them to easily and effectively understand complex issues. This process of implementation is granted by modern instrumentation in conjunction with information technology. The „acoustic camera" is a measurement tool which joined the field of acoustics a few years ago. This technology analyses the actual sound scene, which consists of a superposition of different sound sources, into a visual sound map. The basic principle relies on accurate calculation of the specific runtime delays of acoustic sound emissions radiating from several sources to the individual microphones of an array. An acoustic map of the local sound pressure distribution at a given distance will be calculated using the acoustic data of all simultaneously recorded microphone channels**

I. INTRODUCTION

It is necessary, in current university pedagogy, to present high tech equipment and its principles in an self-explanatory and comprehensible form for the audience. Many of the physical quantities cannot be visually recorded. One of these quantities is also *noise*. Noise visualization process is allowed by acoustic camera.

The configuration containing the acoustic camera is a revolutionary solution of three-dimensional localization of sound emission with their quantitative evaluation and frequency analyses in dynamic mode. The amount of obtained and analyzed information is incomparable with all up to now used methods that leaned on measurements of sound emission in immission point that number is considerably limited. The acoustic camera offers possibilities of ideal frequency analyses of sound sources in distance from few tenth meters up to few hundreds meters. The delivered software equipment is able to localize effectively the sound sources and perform qualitative and quantitative analyses and so form a base for soundproofing arrangements.

The whole measurement and subsequent analyses are characterized by:

- high accuracy,
- high speed,
- dynamic operational mode,
- high effectiveness,
- transparent result processing (coloured acoustic maps, movies, records).

II. WORKING PRINCIPLES OF THE ACOUSTIC CAMERA

Actual commercial beamforming systems, among them the acoustic camera, use a rectangular virtual image plane in order to calculate the run times between microphone array and measurement object. This way the surface of the device under test is approximated, and the z-axis of the array is usually oriented perpendicularly to the image plane. The assumption is made that the device and hence the image plane do not move during the measuring time. Subdividing the image plane into rows and columns results in a finite amount of rectangular display details (pixels) whose centers of area are used to calculate the delays.

State of the art is the simultaneous taking of an optical photo by means of an integrated digital camera and the subsequent automatic overlay with the acoustic colour map. A typical example of an acoustic image is shown in figure 1.

Figure 1. Acoustic image

The acoustic camera is modular and flexible equipment for visualization and localization of sound sources. Trough visualization, accurate results and fast results decreases the development time of following technical arrangements of noise loading reduction. In the figure 2 is shown the configuration of the acoustic camera.

With Beamforming the main information to find the location of the sound is the run time delay between signals to each microphone. The spatial resolution is in direct relation to the sampling frequency in the time domain and the microphone spacing.

To resolve two sources the system needs to be able to detect differences in the characteristic patterns in form of

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run time delays independent of post signal processing. This is independent from the resolution which is determined by the signal frequency.

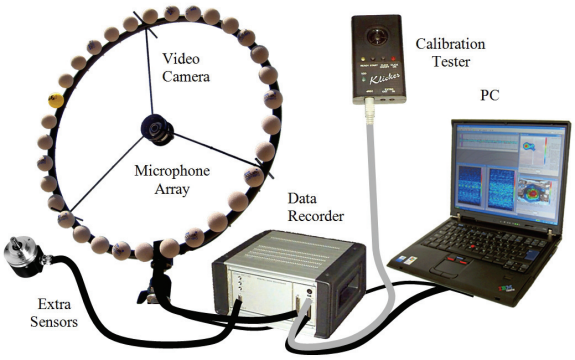

Figure 2. Acoustic image

III. Working Principles of The Acoustic Camera

For working with the software „NoiseImage“ a complex but easy to operate intuitive concept of interactions between space, time and frequency has been developed (Fig. 3). In order to avoid model assumptions about emitter characteristics, only the equivalent sound pressure level is mapped, i.e. in the acoustic image the value is colour coded that would be generated by a point source in a nonreflexive room at the same distance.

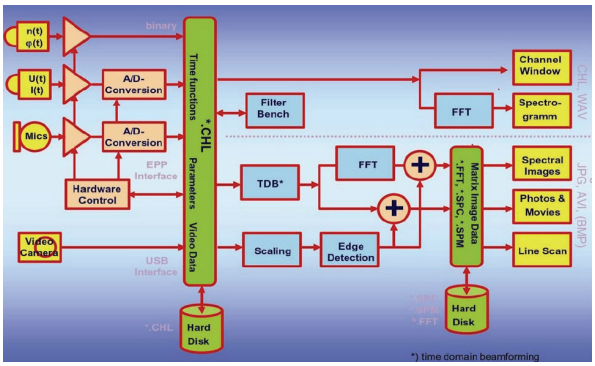

Figure 3. Data structure of the Acoustic Camera – overview

The recorded time functions can be evaluated according to A-, B- or C-weighting. A universal filter bank allows spectral generalisations. In the spectrogram view, noticable emissions can be marked temporally and spectrally simply by a mouse move and can instantaneously be shown as acoustic photo or movie to identify the related sound source. In photos and movies, the reconstructed time function of every location can be saved as wav-file, it can also be displayed as spectrogram or spectrum. All images can be exported as Bitmaps or JPEGs, movies can be saved as AVI. Spectra can be shown in third octave bands. Listening to the time functions of photos and movies is possible by moving the mouse over the picture. This allows to individually recall recordings even many years old.

When a film is saved as AVI, the stereo sound from the recorded time functions or alternatively the reconstructed time function of a chosen location in the image can be integrated into the exported movie. The according location is then marked by a microphone icon. For the analysis of stationary emissions, the so called „spectral frames“ (a type of spectrally sensitive photo) are an additional tool for interactions between image and spectrum. A mouse click into the picture will immediately show the corresponding spectrum of that location, and vice versa selecting a spectral band from the spectrum will show the related acoustic image covering only those selected spectral components.

Saving a high channel recording generates a file (channel: *.chl) with all the relevant information (time functions, preamplifier parameters, date, distance, video image(s), camera parameters, array coordinates, calibration data etc.). So the channel file does not only contain raw time function data but all necessary parameters belonging to a measurement. Motivation for this decision is a maximum independence of the data analysis from the measurement process: A data file can be evaluated correctly even one year later and even by another person not involved in the measuring process itself.

IV. Application in The Industry

There are exemplified applications of acoustic camera at sound measurements of major industrial sources, in this case an industrial area. In the fig. 4, 5 and 6 are shown the views of the analyzed buildings in an industrial area. In the fig. 7 and 8 are shown the noise emission intensity of fan driving. The critical frequencies recorded at the measurement site are evident from spectrogram, see fig. 9. Structure of the entire frequency spectrum is obvious from the fig. 101, where are clearly shown the critical frequencies.

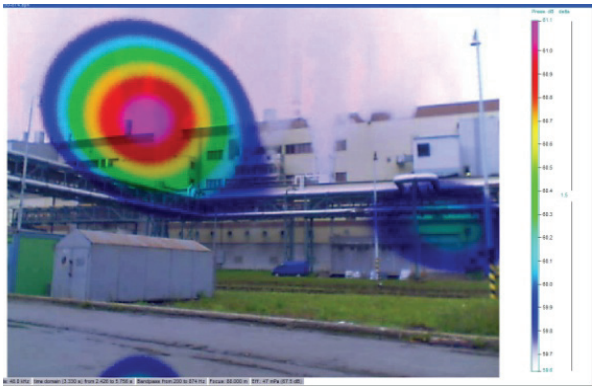

Figure 4. View of the analyzed buildings – 1st source

Figure 5. View of the analyzed buildings – 2nd source

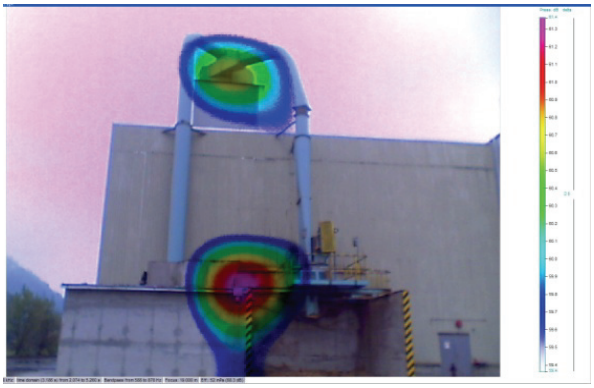

Figure 6. View of the analyzed buildings – 3rd source

Figure 7. Visualization of the noise emission intensity of fan driving

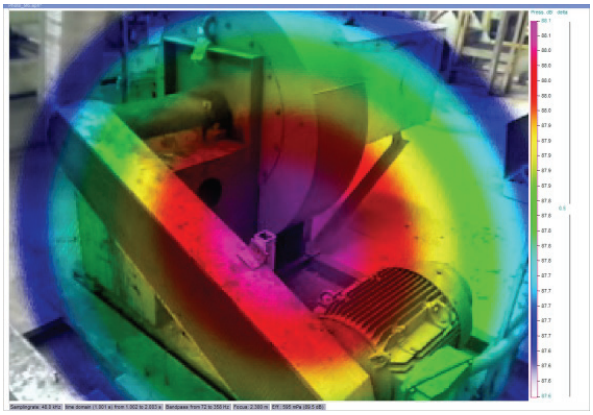

Figure 8. Visualization of the noise emission intensity of fan driving

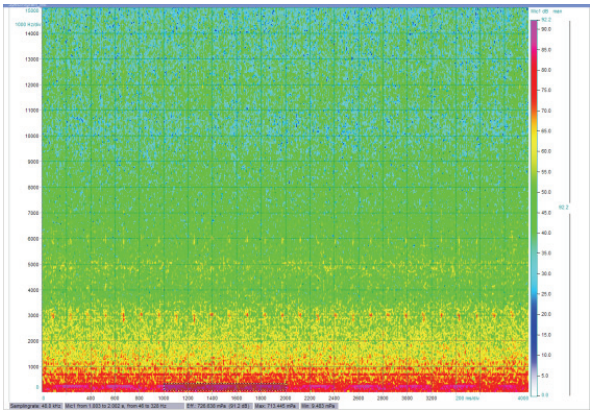

Figure 9. Spectrogram of the emitted noise

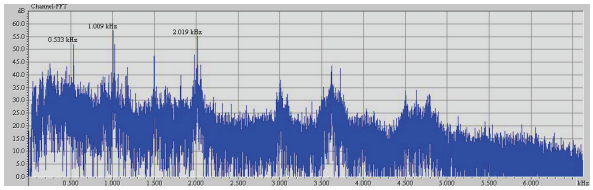

Figure 10. Frequency spectrum of the recorded noise

CONCLUSION

Human being perceives about 95% of information visually. Sight is especially important in education. It affects remembering of presented information and speed of learning. Modern information technologies and their entry into the educational process are a critical aspect increasing efficiency of this process.

The acoustic camera extends the present analyses procedure. Also involves general methods of the analyses like A-level evaluation, tertiary and narrow- band analyses, filters and other options. It makes possible to provide detailed analyses. The spectrogram makes possible for example recording of the sounds in time and in transmission bandwidth. From the acoustic photo one can localize the sources of these sounds, recall the emitted noise in certain points, show critical frequencies and do all this after provided measurement. The acoustic camera is a multisensorial virtual studio for sound sources analyses in detail.

ACKNOWLEDGMENT

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REFERENCES

[1] LUMNITZER, E. - ROMÁNOVÁ, M.: Modelovanie dopravného hluku a hluku z stacionárnych zdrojov v oblasti mestskej zástavby. In: Acta Mechanica Slovaca. roč. 9, č. 2-b eiam 05 (2005), s. 225-228. ISSN 1335-239

[2] Žiaran, S.: Ochrana človeka pred kmitaním a hlukom, Slovenská technická univerzita v Bratislave, 2007, ISBN 978-80-2799-0

[3] Lumnitzer, E., Badida, M., Biľová, M.: Hodnotenie kvality prostredia, Elfa s.r.o. Košice, 2007, ISBN 978-80-8073-836-5

[4] Biľová M., Lumnitzer E. Comparison of measurement methods for acoustical parameters determination of sound absorbers In: AEI ´2010 : International Conference on Applied Electrical Engineering and Informatics 2010 : Venice, Italy, September 7-10, 2010. - Košice : TU, 2010 S. 49-53. 2010.

[5] [5] Biľová M., - Lumnitzer E., Farkašovská Z., Poláčeková J. Evaluation of acustical insulating material properties In: International Joint Conference on Environmental and Light Industry Technologiesv : 18. - 19.11.2010, Budapest, Hungary. - Budapest : Óbuda University, 2010 P. 29-33. 2010.

U. S. Steel Kosice – Employees' training and development

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***Abstract*—These papers introduce the employees training process in U. S. Steel Kosice and the 2010 training review and training costs breakdown. Highlighted are the e-learning programs we implemented in recent years and the different areas of computer-based training we use for employees ´training and development.**

I. INTRODUCTION

U. S. Steel Kosice (hereinafter USSK), a profitable integrated steel company located in Eastern Slovakia, represents a successful partnership of Slovak technical skills and knowledge with strong American plant management and market-oriented business experience. A responsible approach to business is fundamental and permanent principle of USSK which is a leading contributor to the economic, environmental, and social development of Kosice and Eastern Slovakia. The Company supports community projects in healthcare, education, charity, sport and culture.paper, adjust the lengths of the columns so that they are equal. Use automatic hyphenation and check spelling. Digitize or paste down figures.

U. S. Steel Group's Vision:

- A profitable steel company that earns an adequate return for its shareholders and provides sufficient capital to assure its long-term success.
- An innovative steel company that clearly distinguishes itself as the industry leader in providing superior quality and service to its customers, while continuously reducing costs to achieve a status of low-cost producer.
- A company that has respect for all employees, creates an atmosphere which motivates employees to fully utilize their talents, encourages all employees to work together effectively and promptly recognizes and rewards each employee for contributions to the overall success of the company.
- A company that values diversity in its workforce, fosters a safe and healthy workplace, is environmentally responsible and at all times conducts itself in an ethical manner.
- A company in which each employee takes pride in being an important and contributing member.

To achieve this VISION, we must significantly elevate our performance standards and consistently achieve these new levels.

Qualified employees are the basis of every company's success. USSK provides various kinds of training activities for employees and possesses a highly-qualified and professionally skilled work-force. Investment in development of human resources is one of the priorities in the top management interests. [1]

II. TRAINING PROCESS

The USSK training process is a systematic approach that is provided by the Training and development department and consists of the following steps:

1. Needs Definition

First step is to identify all the needs for training activities for our employees. In order to ensure all necessary training, we have to follow legal requirements – both European (such as REACH, ISO, etc.) and Slovak Law (such as Labor Code, Safety Law, etc.). Since we are a part of an international corporation, we also pay attention to corporate strategy requirements / needs or new technology needs and provide employees with training that was set by the corporation for respective year. Another part of training activities comes from the annual employees' performance appraisal and personal development goals (Leadership, Business, Professional, Language Skills training, etc.). Training department also cooperates with Recruiting department and provides the needed training based on the results from the Assessment / Development Center. In case of any finding from QMS / EMS audits, we reflect all needs in our training plan.

2. Planning

As soon as we have all the needs summarized, we prepare the USSK training plan. We use the information system Financial 2000 that allows us to make plans for each organizational unit broken down by quarters. In addition to this plan, we manage „ad hoc" requests, mostly to conferences & seminars, or specialized professional training.

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3. *Realization*

The training is mostly provided by internal resources (especially in vocational, safety, fire protection and quality management training). On the other hand, we use external vendors to provide language, managerial, IT and a wide range of professional training, including seminars & conferences. We use all the existing forms & methods, starting from classroom-based sessions, ending with hands-on or e-learning.

4. *Evaluation*

As for the training evaluation, we compare ourselves to the external market applying benchmark indicators, such as external training cost, training cost / total labor cost ratio, total training cost per 1 employee and training hours per 1 employee, etc.. Moreover, we have been using the Kirkpatrick model evaluating training programs that covers all important areas to make sure the training is administered and performed well.

III. 2010 TRAINING REVIEW

In 2010, we provided 131 900 training activities for our employees, which is almost 12 training activities during the year if calculated per one employee out of the average number of 11 129. We spent 1, 56 mil EUR on external training activities. The breakdown by training areas is in the chart below:

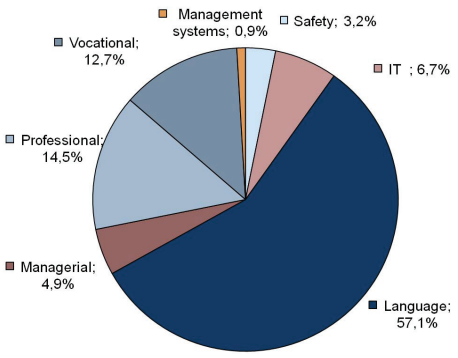

Figure 2. Breakdown of 2010 USSK external training costs by training

As you can see, more than 50% of our external training costs were spent on language training (especially English language training). Managerial, IT and major part of the Management systems training was provided internally, using e-learning programs. Vocational and Safety training is trained especially by internal trainers to ensure compliance with internal rules and procedures. We have our own Interactive Training Center which is used for hands-on training, such as Life Threatening Programs training (incl. Cardinal Rules, Hand Injury Prevention, Energy Control, Fall Protection, etc.). The center was open in 2007 and has special stands for practice. Every year we train more than 11 000 employees (USSK & Subsidiaries) in this center.

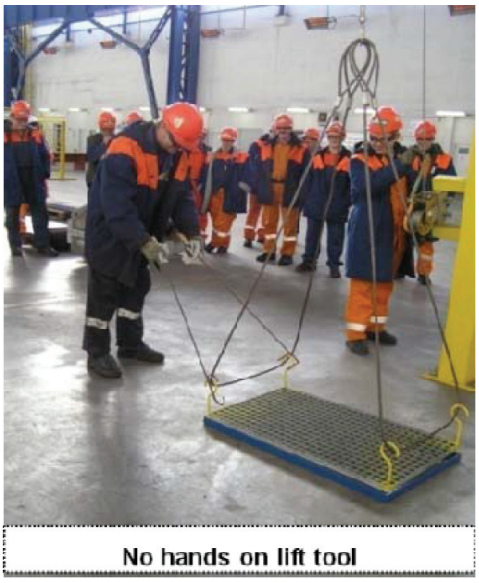

Figure 2. USSK Interactive Training Center

Figure 3. USSK Interactive Training Center

In USSK, we also have our own Welding School for welding training. We train around 2500 employees in average (USSK & Subsidiaries) and additional 20 from external companies. We provide around 60 types of welding courses (duration: from 1 up to 20 days).

IV. USE OF E-LEARNING

Due to rapid changes in technology, new techniques, such as business skills training online via the Internet, are available for employee development that generally offer better results. Time is money and we decided to use e-learning programs not only to save money on training costs but we also realized the setback our business suffers when employees have to put their work on hold and travel to attend training seminars and programs. Online business skills training programs solve this problem by enabling us to introduce employee training through the process of e-learning. Employees can increase their productivity by following these online training programs in the comfort of their office. E-learning programs are available at the place of convenience to the employee.

Employees can understand the instruction of these online training programs at their own pace. With regular seminars and training programs, if the employee is unable to understand a concept it is not always possible to go through it again. Employee can replay any aspect of the program until he / she understands it absolutely. Our e-learning programs allow employee to go through the entire curriculum without having the pressure of time on the mind. At the same time, it is easy to skip the parts that he / she already knows about the issue and save time doing repetitive study. [2]

In cooperation with our IT courses provider, we prepared Microsoft Office and Windows e-learning programs to help our employees with existing excel, word and powerpoint files and respective problems couple of years ago.

In 2008, we started to use our own e-learning programs, technically prepared in cooperation with external vendor, focused on Safety area (Occupational Safety, USSK Cardinal Rules for Administration, Fire Protection and Major Industrial Accident Prevention training), QMS and EMS annual refreshers and basics of managerial soft skill courses (Presentation Skills, Time Management, Teamwork, Effective Motivation, Problem Solving and Decision Making, Work-Life Balance). Employees who have their work PC can access all the above mentioned courses via employee portal placed on the USSK intranet. We work on new courses from both managerial and safety area that should be offered in 2012.

Our e-learning programs were well received and appreciated not only by the users, USSK employees, but also by the jury of the 7th year of Learning Projects Competition "eLearning in Praxis" organized within the ICETA 2010 conference.

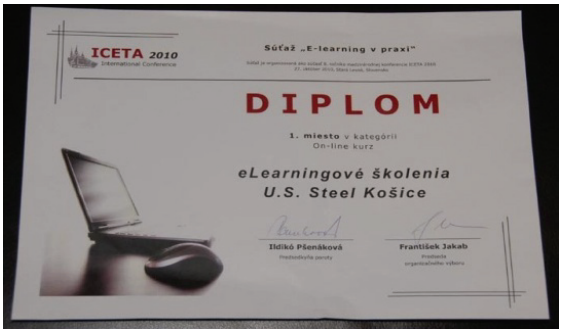

Figure 4. USSK – winner of the 7th year of Learning Projects Competition "eLearning in Praxis"

In 2011, we took another step forward and decided to introduce a new learning tool in language training, online English training program provided by GlobalEnglish. The complex system offers initial placement test, access to virtual classes to talk with life teacher, focus on both general and business English, available vocabulary and translator for general and special areas (industry, finance, legal, etc.), communication toolbar with email templates, library and interesting text and audio. The system enables to study English and practice and improve all aspects of foreign language – grammar, listening, reading, pronanciation, speaking and understanding. The system offers user-friendly, interactive and multimedial content.

GlobalEnglish is available for access via internet, so our employees can use it not only at work but also at home using their privat PC in order to manage their time. GlobalEnglish offers various online tests and quizzes that enable employees to judge the present knowledge base of the participant. Some people would say, that online training doesn´t provide the competitive spirit, but with chat rooms and virtual discussion rooms coming alive e leaning programs have given a new meaning to interaction. Similar ranked employees all over the globe are able to compete as well as gain insight from each other. Only e-learning can bring together such a large group of students.

GlobalEnglish performance and productivity tools will be soon accessible across more platforms and devices. We believe that the combination of on-line learning tool and classroom training provides our employees with sufficient training and enables them to progress in their English.

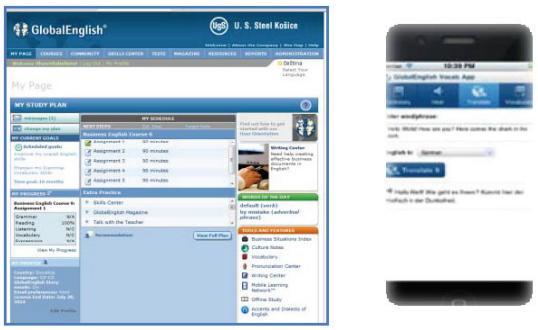

Figure 5. Global English site and mobile application

V. Applications and System Used

Since 2000, when U. S. Steel Corporation acquired former Východoslovenské železiarne (VSŽ) Košice (East Slovakian Ironworks, Košice), an internal information system Financial 2000 is used in our company to manage different activities. In Training and development department we use the special HR module for training requirements recording for each employee (job position description), training plans preparation, training schedules and invitations as well as training attendance recordkeeping. It is not a learning management system, but we modify and enhance the system continuously to meet our needs. As mentioned above, the elearning courses as accessible via USSK employee portal which is linked with the IS Financial 2000. We can schedule courses for each employee, list all attended and planned training activities and offer all elearning courses (both mandatory and voluntary) via this portal. As soon as the course is completed by the employee, the date of

completion and the test result (in case of mandatory training) is recorded in IS Financial 2000, so we can keep track of every training activity we provide – classroom as well as computer-based.

E-learning programs are evaluated electronically. An email is sent to employee as soon as he / she complete the course with a questionnaire focused on training program satisfaction evaluation. Training administrators can see the evaluation statistics and the employees' thoughts and satisfaction. We are happy they like it and appreciate this method of learning.

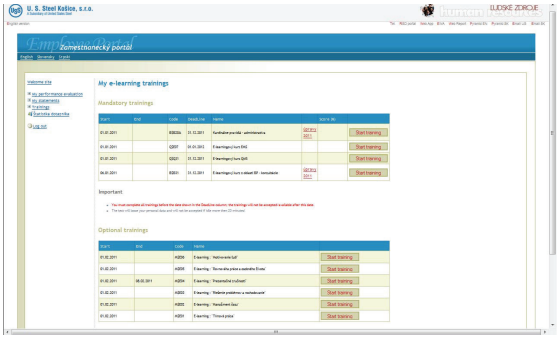

Figure 6. USSK Employee portal – My e-learning trainings site

VI. Conclusions

Using computer-based training has many advanteges for both employee and our company. We can save employee´s time, allow him / her to take the course when suitable. The training costs per employee are significantly lower compared to classroom training. Unfortunatelly, we can only use this method of learning for employees who have PC and access to USSK intranet and / or internet. The majority of our employees are working in Operations – blue collar workers with no access to computer at workplace. We will continue to train them in classrooms and training centers also in future. Especially vocational and safety training needs to be trained by a live trainer who can demonstrate activities and answer questions right away and onsite. We will also continue to look for new topics for e-learning programs as well as for new methods and ways of employees training and development programs.

References

[1] U. S. Steel Košice, s.r.o. Corporate Info - http://www.usske.sk/corpinfo/corpi-e.htm

[2] Benefits of using E-Learning for Employee Training and Development http://www.elearningyellowpages.com/BusinessSkills/BusinessSkillsNews&Views-273.html

Collaborative Resource Sharing for Computer Networks Education Using Learning Objects

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***Abstract*—The digital repository of learning objects for computer network education is presented. The repository was designed to enable sharing localised study materials among Czech instructors of Cisco certification programmes. The repository works as a digital library, with the set of metadata elements used for tagging and rating learning objects.**

I. INTRODUCTION

Cisco certificates are computer networking certificates that are valid and accepted by employers worldwide. The relevant training is provided by specialized centres, often as part of university study programmes. Cisco Systems Company provides official learning materials to instructors and learners through Cisco Networking Academy Program (NetAcad), online learning system.

The objective of our paper is to describe LORENA, the shared repository of localised NetAcad learning materials for Czech students to explain how the repository can be integrated with the learning management systems.

II. NETACAD

NetAcad was founded in 1997 as a partnership between Cisco System and educational, business, government and other communities all over the world with a vision to train new network professionals. The educational program uses e-learning and related tools such as instructors and students training, web portal, network simulators, testing exercises, study materials, collaborative tools, network simulation and exercises in laboratories. The goal of this effort is to teach students how to create and manage real computer networks. More than 2 million students studied in more than 10 000 academies in 165 countries worldwide [2], including the Faculty of Informatics and Management, University of Hradec Králové (FIM UHK).

The computer network education at FIM UHK is based on combination of distance study hours in virtual education environment and following practices in laboratories. There are many supporting tools, out of which very important is Packet Tracer – the network simulator that enables students to simulate network topology, set parameters for active parts of computer network etc.

For theoretical preparation and study process support there are two environments available at UHK: NetAcad provided by Cisco Systems Company and e-learning system Web-CT/Blackboard which is used at FIM UHK for delivering online learning materials in most study programmes and courses.

NetAcad program is considered as the Global Learning Network. This network is a collection of hardware and software that creates international distance learning system containing the following parts:

- Content management system,
- Content distribution system,
- Web server,
- Cisco Learning Institute Virtuoso,
- System maintenance tools.

Cisco headquarters is interconnected with local centres (academies). Every academy is allowed to use its own web server to distribute the content from central servers. There is no need to download the whole content of central server, only relevant parts can be used. These adjustments improve the performance and increase efficiency of learning process. The content distribution system is responsible for transferring units of educational data to students. The Cisco Learning Institute Virtuoso is a set of tools used for creating multimedia content. If there were more information required, the system finds and displays this it including the most effective way of data distribution.

Following functionalities are available in NetAcad [2]:

- Course study materials,
- Hands on labs,
- Continuous (chapter) tests,
- Final exams,
- Practice exams,
- Tools.

Although there are English NetAcad learning materials available, in numerous countries the localized study resources are prepared and enhanced. Instructors tend to define their own guidelines and have their own best practices that make the learning process more efficient. Sharing these resources is highly preferred, typically among educational institutions with the same or similar structure of computer network study programmes, the same organization of the academic year etc.

III. COMMUNITY OF NETACAD INSTRUCTORS

The NetAcad community involves computer network instructors from secondary schools and universities. The academies were organized hierarchically, with the regional academy on the top. At the moment of preparation of this paper, the hierarchy of academies is under reconstruction. The academies are planned to be

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associated with the Academy Support Center and the instructors will be taught at the Instructor Training.

For instructors, there is the iPortal where any kinds of problems related to the computer network training can be discussed and news, workshops proposals, competitions etc. can be announced. The digital content at the iPortal is well organized on blog principles. The main group for Czech instructors is called „CZ.All“, with 216 instructors from 77 academies. Thanks to the strong community of Czech instructors who are willing to cooperate, new events and activities are organized frequently. For example, the competition Networking Academy Games was prepared by instructors from over ten academies. Another important activity is the preparation of localized learning materials: Czech resources extend the amount of study materials for Czech students and lecturers. To share these resources, the repository of learning objects was created.

IV. LEARNING OBJECTS

Learning object is defined by IEEE as "any entity, digital or non-digital, that may be used for learning, education or training" [1]. Chiappe defined learning object as "a digital self-contained and reusable entity, with a clear educational purpose, with at least three internal and editable components: content, learning activities and elements of context. The learning objects must have an external structure of information to facilitate their identification, storage and retrieval: the metadata."[11].

Metadata descriptions of learning objects were standardized by several initiatives. The standards enable further exchanges of learning objects among learning systems, including their automated processing. One of first metadata standardization initiatives, Dublin Core (DC), defined essential metadata elements that are necessary for description of any resource. There were 15 core elements defined in the scope of DC. Their specification is flexible and no element is obligatory, their meaning can be precised. The Dublin Core specification does not define the syntax, XML format is used frequently to achieve the portability of metadata records [5].

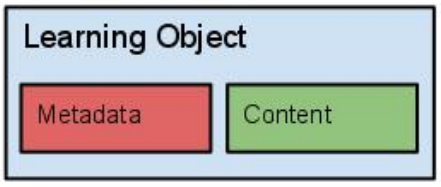

Figure 1: Learning object scheme

The DC specification itself is too general, therefore impractical for describing the learning objects. The more usable standard is LOM, the IEEE Standard for Learning Object Metadata no. 1484.12.1. This standard defines 58 metadata elements in 9 categories:

- General,
- Lifecycle,
- Metametadata,
- Technical,
- Educational,
- Rights,
- Relation,
- Annotation,
- Classification.

As well as DC, the LOM elements are not obligatory, therefore also learning objects with no description are LOM standard compatible. For practical use, the application profiles have to be specified. Typically the profile are designed for regional or institutional usage, e.g. UK LOM Core for Great Britain, CanCore for Canada, ARIADNE for European academic institutions etc. The LOM standard supports three notations [5]:

- Resource Description Framework (RDF),
- Extensible Markup Language (XML),
- ISO/IEC 11404 (standardized abstract data type language).

Other IEEE projects (1484.12.2-4) are focused on standardization, too.

Not only metadata descriptions, but also learning objects have to satisfy standards to simplify further reuse and interoperability. One of these standards is ADL – SCORM (Sharable Content Object Reference Model) produced by Advanced Distributed Learning Initiative. From 1997, ADL provided standardized format that interconnected the isolated formats used by particular providers of learning objects. The main task of ADL was to interlink the American consortia (IMS, IEEE, AICC) with providers of standards (W3C, ISO). The results of this effort is SCORM, enabling the interoperability built on XML. The latest SCORM version is from 2004 [9].

V. LEARNING OBJECTS REPOSITORIES

Numerous repositories of learning objects were built. Most of them are defined as Learning Object Repositories (LOR), or more generally Digital Libraries. LOR are accessible for registered users who can full-text search for learning objects, browse the tree of categories etc. Precise metadata description of the stored content increases the usability of the repository.

In article [7] are comparison of the following Digital Libraries described.

Fedora – it is a flexible system based on principles of service oriented architecture. Nevertheless, flexibility is concerning only to content of the repository, Fedora is capable to store and access any digital content – this does not stand for flexibility of whole information system. Fedora does not contain user interface.

DSpace – is complex system that contains repository including user interface. Nevertheless, DSpace is not flexible system – it is not possible to customize certain parts and behaviour of the software.

Greenstone – supports distributing collections via removable media. In this paper we discuss service oriented architecture, process based approach etc. – nevertheless contemporary technologies do not allow creating applications, which are based on these principles, which are multiplatform and which supports running from removable media.

EPrints – is primarily intended for scientific publications (digital objects are not modified very often). This system uses statically generated pages of user

interface. EPrints supports multiple archives under one instance (logical libraries).

CDS Invenio – is a complex and flexible system, which uses third party products for certain use cases. Customization of the system is complicated and may be expensive. There are strong dependencies on other products, which can cause problems with incompatibility between different versions.

DILLEO – is primarily intended for educational purposes. It is typical three-tier architecture with thin client. The application consists from set of components producing tight coupled relations. DILLEO – similarly to the most of other digital library systems – does not support service oriented architecture and does not stand for flexible system.

Most of presented systems are specific oriented (e.g. EPrints or CDS Invenio), whereas usually respect needs and requirements of institutions, where were created. There are a few digital library systems, which are complex; nevertheless the solution is not optimal and sufficient enough. Table 1 contains comparison of architecture and features of selected digital libraries systems.

In article [7] the following results of comparison from perspective of architecture of information systems are summarized:

Table 1 – Comparison of digital library systems

	Fedora	DSpace	Greenstone	EPrints	CDS Invenio	DILLEO
User interface		*	*	*	*	*
Dynamically generated pages	*	*	*			*
Customizable searching					*	
Customizable metadata formats	*				*	
Flexibility of the system	*				*	
SOA principles	*					
Process based approach		*				
Removable media (DVD, CD…)			*			

In general, flexibility of described digital library systems is very low. Only Fedora is based on SOA principles, CDS Invenio is a flexible system, nevertheless customization is relatively complicated. None of these systems (except DSpace) support process based approach, typically for the approval process. Very problematic is also customization of searching algorithm and modifying of used metadata format. Any customization and modification of these systems may be complicated and represents high costs for an institution.

VI. LORENA System requirements

LORENA is a **L**earning **O**bject **Re**pository for **N**et**A**cad. The basic requirements for the repository are as follows:

- Well structured internal organization of learning materials according topics, themes, last update, rating etc.,
- Web access without the need to install any special applications,
- Simple interface for uploading and downloading materials,
- Rating system for measuring the quality of materials,
- Support of sharing multimedia,
- Support of threat discussion related to particular learning materials,
- Advanced search,
- Tag support,
- RSS support.

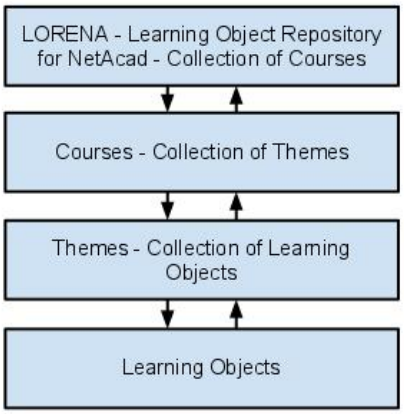

Figure 2: Logic hierarchy of the repository LORENA

The metadata description of the learning object should consist of:

- Name of author,
- Document type – text, image, audio, video, configuration file etc.,
- Description of the content,
- Last update,
- Ranking assigned by users,
- Related chapters, modules or collections where the object is reused.

In the case of requirements, customizable metadata formats and high flexibility of the systems are highly recommended. Fedora seems to be adequate to the requirements. The main advantage of Fedora is that Fedora is based on principles of service oriented architecture (SOA). Service oriented architecture is a concept for building and integration of information systems and applications. Fedora provides repository service exposed as web services with well-defined application interfaces via REST or SOAP protocols. The key feature of Fedora is that repository can store all types of digital content and its metadata [4]. Due to service

oriented architecture Fedora provides high level of flexibility of content (not whole system). Fedora does not contain the user interface (presentation tier). An institution should implement the user interface by other means [7].

Reusing Learning Objects from LORENA is presented on Fig.4.

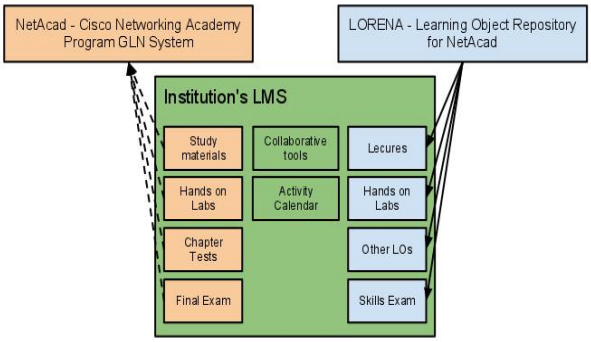

Figure 3: Reusing Learning Objects from LORENA and links to NetAcad environment in institution's LMS

Particular learning object can be exported from the repository and reused in LMS of the educational institution (Blacboard in case of UHK). The advantage of that the e-course in the LMS enables defining sequences of learning objects with links to the NetAcad. Thanks to the interest and enthusiasm of instructors, the quality of materials should be high.

VII. Conclusion

Czech universities prefer either open source e-learning systems (Moodle), or licensed products (Blackboard). In the scope of the computer network courses, students of informatics are motivated to obtain certificates. Official study materials are available, but the experienced instructors prefer their modified and localised resources.

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References

[1] Learning object – IEEE definition (2002) Learning Technology Standards Committee, p45

[2] Bodnárová, A., Soběslav, V., Horálek, J., Feltl, M. (2009) Implementation of Career Certification in higher Education Process. In Emerging e-learning technologies and applications : 7th international conference. Elfa, Košice, Slovakia, pp327-330, ISBN 978-80-8086-127-8.

[3] DSpace, Digital Archive Project, http://dspace.org

[4] Fedora, Flexible Extensible Digital Object and Repository Architecture, http://www.fedora.info

[5] Drášil, P. et al: Relevantní standardy v oblasti e-Learningu, Technická zpráva CESNETu číslo 24/2004, aviable at: http://www.cesnet.cz/doc/techzpravy/2004/elearning/elearning24.pdf

[6] Neven, F., Duval, E. (2002) Reusable learning objects: a survey of LOM-based repositories, Proceedings of the tenth ACM international conference on Multimedia, December 01-06, 2002, Juan-les-Pins, France

[7] Kokorceny, M., Bodnarova, A. (2010) Comparison of digital libraries systems. In Advances in Data Networks Communications Computers - 9th WSEAS International Conference on Data Networks, Communications, Computers (DNCOCO 10), Faro Portugal, pp150-152, ISBN 978-960-474-245-5

[8] Nash, S. (2005) Learning Objects, Learning Object Repositories, and Learning Theory: Preliminary Best Practices for Online Courses. In: Interdisciplinary Journal of Knowledge and Learning Objects, 1, pp217-228.

[9] http://www.adlnet.gov/capabilities/scorm

[10] Mikulecký, S. (2005) Digital library of learning objects, University of Hradec Králové.

[11] Chiappe, A. (2007) Toward an instructional design model based on learning objects, In: Educational Technology Research and Development, Springer, Boston, pp671–681.

[12] Olševičová, K., Mikulecký, S. (2003) The possibility of semantic searching in educational e-resources. In: DEL2003, Prague.

MINERVA 2.0 – Slovakia into the first league

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Abstract - **The Minerva 2.0 strategy was drawn up by the Government of Slovakia´s Plenipotentiary for Knowledge Economy in collaboration with the Ministry of Finance, Ministry of Education, Science and Sport and The Ministry of Economy. The goal of the strategy is to support the development of knowledge economy in Slovakia through 26 concrete and specific measures in three main areas – Development of Human Resources, Systematic support of Scientific and Innovative Research and the Reform of the Institutional and Legal Frameworks. The policies of the Minerva strategy will be implemented through close collaboration of the Government, educational and research establishment and business.**

I. INTRODUCTION

The economic performance of the most important world economies for the year 2010 along with the 2011 forecasts suggest, that the global economic recession is over. Thanks to its strong competitive position, the Slovak economy can look forward to a period of economic growth. Economist forecast that just as before the crisis, Slovakia will once again be among the fastest growing EU member states.

The Slovak republic owes its current competitive position to two waves of successful reforms. In the early 90s of the last century, a post-socialist transformation took place in Slovakia, forming the basic market institutions, mechanisms and environment. IN the years 1999 to 2005, a second wave followed, forming the necessary conditions for long term economic growth.

However, competitiveness cannot be based on an endless series of cost cutting initiatives. IN order to make the best use of our current position and in order to ensure that the painful reforms of the past are not in vain, it is crucial to follow them up with a third wave of systemic, complex measures ensuring the continued competitiveness of the Slovak economy. Unlike past reforms though, we do not advocate further restrictive measures, on the contrary, today it is necessary to make good use of existing economic growth and invest in the creation of a modern innovation ecosystem.

It is generally known that from a long term perspective, it is not possible to keep raising living standards and at the same time base the competitiveness of the economy on low input costs. The key to long term competitiveness is therefore productivity growth, based on innovation. The purpose of a knowledge economy is to generate an environment, in which education, research and development and entrepreneurship sectors maximize their cooperation with a goal of not just generating new ideas, but also turning those ideas into new real world products or more effective processes.

The primary objective of the education system is therefore to train curios and creative young people capable of teamwork, able to process new information, and willing to undergo certain risks. The research and development sector must attract some of these people and create an environment in which they can dedicate themselves to cutting edge basic and applied research. Other educated people shall turn entrepreneur, and they need to be able to transfer the ideas generated in R&D into the real world and must be able to share the profits of such endeavors with the authors of the ideas and the institutions in which the ideas were generated. Yet another group of educated people shall find employment in existing firms, and use their skills to observe and improve existing processes, thus further increasing the productive potential of the Slovak economy.

In other words, the goal of building a knowledge economy is to create an environment, in which people with a high quality education work on cutting edge ideas in Slovakia, and their entrepreneurial colleagues use these ideas to generate new job opportunities and improve the living standards of their compatriots through innovative technological firms. Instead of serving as an assembly line reproducing the ideas of others, Slovakia will thus become a place where we will generate our own work processes and develop our own products to be assembled at home or in other, less developed countries.

In the past, the rate and scope of structural reforms was significantly better in Slovakia than among its neighbors. We need to keep the same ambition for the creation for a knowledge economy: take over the Czech Republic, catch up with Austria, and get Slovakia into the first league.

II. THE STATE OF KNOWLEDGE ECONOMY IN SLOVAKIA

The need to develop innovative potential and to create a knowledge economy is old news in Slovakia. The foundations for a knowledge economy were laid already in 2005 by the Minerva competitiveness strategy, the goal of which was to set the course for Slovakia for the following electoral periods. However, due to a large number of intended measures that were not coordinated and prioritized effectively, the momentum of Minerva was lost and the process of building a knowledge economy fragmented among a number of institutions and a number of various strategic plans.

The initiatives for supporting the development of a knowledge economy have then been incorporated into various strategic documents and governmental activities such as for example the Innovation strategy, the strategy Slovakia 21, the National Strategic Reference Framework and the National Program of Reforms.

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Despite all this, the state of knowledge economy in Slovakia remains pitiful. Slovakia lags behind not only the most advanced OECD countries, but also behind Poland, Hungary and the Czech Republic in a number of areas with critical importance for knowledge economy. We are the only Visegrad Four (V4) country with no University in any leading world ranking. We have the lowest share of innovative firms in the economy of all V4 countries. And in the ranking of top cited scientific articles we are lagging not only behind the V4, but also behind countries such as Brazil, Turkey or Mexico. Slovakia is far behind the leading performers in Europe and our long term position is deteriorating despite the fact that Slovakia is nowadays among the five fastest growing EU members.

Slovak investments into education, research and development rank among the lowest in OECD. The number of foreign students in Slovakia is negligible, while the flow of students out of Slovakia is among the highest in OECD. In the innovation rankings of EU countries, Slovakia fell from 18th to 23rd rank between 2009 and 2010. Even though a number of strategic documents refer to knowledge economy, high level political coordination and implementation support is entirely absent.

III. Specific measures aimed to develop knowledge economy in Slovakia

Knowledge economy represents a complex ecosystem, in which the sectors of education, research, development and entrepreneurship are delicately intertwined. Table 1. Shows the main areas and problems identified.

Area	Problem
Education	Low quality of education
Links between education and R&D	Lack of high quality professionals
	Weak functioning of key institutions
R&D	Ineffective and insufficient financing of R&D
Links between R&D and entrepreneurship	Weak technology transfer process
Entrepreneurship	Few and weak domestic technological firms
	Weak R&D activities of international firms
Links between entrepreneurship and education	Education cut off from industry
	Lack of entrepreneurial skills training
Systemic failures	Weak political coordination
	Administrative burdens
	Lacking support for international mobility

Table 1. An overview of problems in Slovak knowledge economy

A. Education

Problem: Low quality of education

A necessary condition for the development of knowledge economy is an educational system capable of training people to think independently and creatively. In the information age, it is crucial for the education system to teach young people to effectively receive, process, or generate new information, not to primarily force them to memorize existing information that rapidly becomes obsolete. The current educational system fails reflect the needs of the industry and many employers begin to complain about lack of preparation and independence of university graduates.

In the field of education, Slovak republic lags behind the rest of V4 and the average of OECD. While Poland and Hungary rank in OECD student rankings at least at average levels and their results are improving overtime, Slovak students have been consistently placing below the OECD average for the past six years. Slovak high school students reach the OECD average in mathematics and in the area of collecting information, but they fall short in sciences and in evaluating information. Our students thus perform worst in exactly those areas, that most require critical thinking and are most important for the development of a knowledge economy.

The need for a fundamental change in our approach to education is illustrated by the McKinsey study How do the best education systems keep improving: „the systems on the way from average to good, in general characterized by less well trained teachers, strictly control the educational process because the minimization of differences among classes and schools is a key performance driver at this stage. On the contrary, systems moving from good to excellent, characterized by more experienced teachers, offer only more general frameworks and syllabi, because the creativity of teachers, sharing of ideas and innovations within and among schools are a motor for further improvements.“ Slovakia has an ambition to create an excellent educational system, but it is trying to achieve these goals using tools more adequate to less developed systems.

Cause	Solution
Outdated educational methods	Partially resolved by syllabus reform and expansion of rights of school directors in the last educational reform. The effects must be given time to demonstrate, the process will be aided by best practices exchange
Low quality of teachers	Improvement of teacher education and best practice exchange
Conservative school management	Improvements in teacher quality will generate pressure on management for further improvements
Weak connection to world trends	Support for student and teacher mobility
Professional training weakly connected to industry	Lifelong learning system

Table 2. Causes and proposed solutions

B. Links between education, research and development

Problem: Lack of top practitioners

Best students leave to study abroad, and the top graduates move to the private sector. As a result, the universities are lacking a strong middle generation. To some extent, quality is maintained by aging professors, but they lack adequate support from driven middle aged successors. As a result, continuity is lost, and if the situation is not addressed soon, it could result in an irreversible decline of higher education, followed by the rest of the economy.

There is no one to replace the departing students and professors, because the mobility into the Slovak republic is significantly restricted by visa policies, policies for residency of foreigners, as well as various administrative barriers by immigration officers, ministries and embassies. According to OECD data, in 2007 10,3% of Slovak students studied abroad (more than in Bulgaria, comparable with Uzbekistan and Morocco), but less than 1% of foreign students studied in Slovakia (one of the lowest values in OECD, comparable with Turkey or Poland, way below Hungary or Czech Republic) .

To reverse this process, we need to support high quality researchers and scientists so that they do not need to emigrate or move to the private sector, and bring top foreign researchers to Slovakia, whether for a limited time or permanently.

The lack of high quality professionals is not tied only to teachers or researchers. It also applies to top managers and administrative personnel, who could bring foreign innovative approaches to Slovakia, improve the student experience, and support university professors and scientists in their work.

Cause	Solution
Low R&D budgets	Excellence initiative a new funding schemes
Infrastructure insufficient for cutting edge research	Some improvement due to structural funds, followed by world class infrastructure
Bad physical work environment	Building reconstruction program
Bad mental work environment	Excellence initiative and installation grants will improve the quality of work teams. Popularization programs will help attract more young talented students. Governance reform of universities and SAV will create more space for innovation.
Barriers for access of foreign students, researchers, teachers, and scientists	Migration policy (S.6)

Table 3. Causes and proposed solutions

C. Research and development

Problem: Weak functioning of key institutions

Slovak universities and science institutions regularly place at the tail end of OECD productivity rankings. No single Slovak institutions made its way to any of the leading world university rankings. Producing less than one scientific article per year per person in 2008, Slovakia belonged to the least productive countries in OECD. The situation is even worse among the 1% of top cited articles, where in the years 2006 to 2008 Slovak institutions represented less than 0.1%.

Cause	Solution
Lack of incentives to cooperate with private sector	Governance reform of universities
Lack of incentives to produce high quality outputs	Governance reform of universities, Reform of the Academy of science, New funding system for R&D
Legal barriers preventing the academy of science from cooperating with private sector	Reform of the Academy
Focus on quantity of students instead of quality	Governance reform of universities
Low quality management of academic institutions	Governance reform of universities and Reform of the Academy
Lack of high quality personnel	Measures 2 – 5

Table 4. Causes and proposed solutions

D. Links between R&D and entrepreneurship

Problem: Inefficient and insufficient financing of research and development

The volume and structure of private and public funding of R&D in Slovakia significantly lags behind the needs of a modern knowledge economy. Volume-wise, Slovakia is at the tail end of EU and OECD countries. Although the overall volume of public R&D funding is growing rapidly thanks to EU structural funds, the structuring and expenditure rules is absolutely wrong. Merely in the last three years, more than one billion euro was invested without any clear strategy (from the point of view of public expenditure and obligations). On the other hand, Slovakia lacks a number of key mechanisms for providing essential state support in particular stages of R&D, necessary due to standard market failures such as positive R&D externalities. In particular, there is no support for private research that leads to new technologies or solutions for specified economic or societal problems.

The decisions about the funding for education and R&D takes place on too many levels. The vast majority of public R&D expenditures outside the scope of EU structural funds In Slovakia take place in the form of non-competitive institutional financing. As much as 94% of all resources dedicated to academic research flows into generic funds, managed and allocated by the universities and the Academy. As much as 80% of these funds are

directed towards basic research, significantly more than the OECD average.

Cause	Solution
Low national investment into R&D	The implementation of the majority of the proposed measures generates room for more effective financing of R&D
Low private sector investment into R&D	Stimuli. support for innovative companies
Existing funding schemes take little account of quality and results	New grant scheme for science
Too many resources are directed towards generic institutional support	Governance reforms of the universities and the Academy
Undirected and uncoordinated use of research institutes ran by ministries	Grant system for applied research
Inefficient use of structural funds	World class infrastructure for top research
No financing from own resources	Will allow universities to profit from their own research activities and will make it possible to reinvest in R&D

Table 5. Causes and proposed solutions

Problem: Weak technology transfer system

Thanks to the adoption of the Bayh-Dole act in the USA in 1980, US universities were granted the right and responsibility to patent results of research financed from federal funds The Universities have thus gained an ability to license the results of their research and profit from its commercialization. The Universities have responded by forming a well thought out professional system of specialized policies and offices, whose role is to protect the intellectual property of the universities and facilitate the transfer of knowledge and ideas to the commercial sector. In 2004, the income of universities from licensing rights exceeded 900 million USD in the USA, 80 million dollars in Australia, or 3 million euro in Switzerland .

The Slovak intellectual property law on the other had provides only a weak protection for the ability of Slovak universities to claim a share in the inventions discovered on their premises. The law also fails to properly motivate the universities to actively assist its students, teachers and scientists to commercialize the results of their work.

The legal status of universities and research institutes and the rules governing their asset management create barriers for cooperation with entrepreneurs. Despite low equipment utilization rates, institutions are often not allowed to make this equipment available to entrepreneurs who are interested in using the equipment for applied R&D and are willing to let the institution share in the benefits of the research.

The result is an extremely low patent activity of the universities. Out of more than 4 thousand patent applications filed by the EÚ member states and over 16 thousand in all of OECD in the years 2004 - 2006, only two applications originated from Slovak universities, comparing to 13 Czech and 124 Austrian applications.

Cause	Solution
Lack of incentives	National technology transfer system
Lack of awareness about the benefits of commercialization among scientists	National technology transfer system
Problematic IP legislation	IP legislation and property management rules
Problematic legislation related to public asset management and management of assets financed by public or European funds	IP legislation and property management rules
Lacking infrastructure	World class infrastructure for top research
Lack of qualified personnel managing transfer	National system for technology transfer

Table 6. Causes and proposed solutions

E. Entrepreneurship

Problem: Few and weak domestic technological firms

Newly formed companies represent the main source of economic competitiveness and long term job creation. However, too few truly innovative firms are formed and flourish in Slovakia. According to the structure of the work environment, Slovak firms belong amongst the least innovative in all of OECD. The number of small and medium enterprises that introduce innovations in products or processes is deep below EU average and falling. At the same time, firm expenditure on R&D is declining as well, and the number of SMEs dedicated to or cooperating on innovation is falling.

Cause	Solution
Lack of an entrepreneurial spirit	International system of technology incubators
Lack of capital	JEREMIE and SBIR
Legislative barriers	IP legislation
Legislative barriers for foreign entrepreneurs	New migration policy (link later)
Weak technology transfer	National technology transfer system
Weak access to international knowledge and resources	International system of technology incubators

Table 7. Causes and proposed solutions

Problem: Weak R&D activities of international firms

Despite the presence of a large number of technologically advanced multinational corporations such as CISCO, IBM, Volkswagen, Kia and so forth, almost none of these corporations have significant development centers in Slovakia or invest heavily in R&D. On the contrary, the most inventive and capable employees are often transferred abroad. Industrial investment into R&D in Slovakia has fallen from 0.5 to 0.25% of GDP between 1998 and 2008, in stark contrast to EU average of 1%, OECD average of 1.5% or Austria, where industrial

investment in R&D grew in the same period from 1% to almost 2% of GDP .

In contrast to Bratislava, a significant number of large corporations have established R&D centers in Brno. R&D centers of large corporations play a vital role in the economy not only because they provide additional employment, but also because they help to anchor the related manufacturing processes. While the assembly line can in principle be moved fairly easily, it is much more difficult to relocate major R&D centers, because the number of suitable locations is much more restricted.

There is almost no direct or indirect governmental support for industrial R&D. While Austria, the Czech republic, and Hungary invest between 0.1 and 0.2% of GDP into government support for industrial R&D and as many as 22 EU member states offer fiscal stimuli for this reason, in Slovakia the financing of industrial R&D flounders around 0.025% GDP.

Cause	Solution
Lack of incentives	World class research infrastructure will generate an environment attractive for private research centers, Stimuli for industrial R&D will provide additional funding
Administrative barriers	Debyrocratisation of EU funds, Public procurement

Table 7. Causes and proposed solutions

F. Links between entrepreneurship and education

Problem: Education cut off from industrial needs

The supply of existing professional training does not adequately match the industrial demand. Even though a strategy for lifelong learning was adopted in 2007 in Slovakia and even though it was followed by an act on lifelong learning, neither has been thoroughly implemented, especially concerning the acceptance of informal training of professionals.

The growth of a knowledge economy does not depend only on high tech innovation. The diffusion of existing technologies and processes throughout the economy plays an equally important role. A large number of productivity improving innovations can be well known in the country or within the sector, and yet they may be new and innovative for most individual firms. The lack of lifelong education programmes slows down such diffusion of innovative practices.

Cause	Solution
Conservative school management	Lifelong education system will generate incentives for schools to cooperate with industry
Administrative barriers preventing firms from offering courses on proprietary technology	Lifelong education system

Table 8. Causes and proposed solutions

Problem: Lack of entrepreneurial skills training

Even though proficient scientists and researchers are very important for the economy, innovative enterprises are needed to develop their ideas and bring them to practical use. But such companies need well trained managers as much or more than proficient researchers. However, educational programmes focusing on the development of an entrepreneurial spirit (as opposed to a purely academic study of management or accounting) are largely absent in Slovakia.

Cause	Solution
Outdated educational methods	best practice exchange and support for practical entrepreneurship training
Low quality of teachers	best practice exchange

Table 9. Causes and proposed solutions

G. Systemic failures

Problem: Lack of political coordination

Even though a number of strategies were formulated in Slovakia to build an innovation system or a knowledge economy, none were implemented successfully so far. To preserve the momentum of the reforms and overcome the natural institutional resistance, it is crucial to ensure that the reform process receives sufficient attention and support from the top political leadership and to coordinate and drive all initiatives not only at the time when the action plans are written, but also throughout the entire implementation process.

Cause	Solution
Lack of top level political coordination	Government innovation council
Lack of mechanisms for the collection and evaluation of information concerning the implementation of planned measures the actual impact of those measures	Action plans formulated based on this strategy will contain specific objectives, the Government innovation council shall monitor progress towards reaching those objectives

Table 10. Causes and proposed solutions

Problem: Administrative burden and administrative barriers

Whether we examine the system of school inspection, the organizations managing EU structural funds, or the public procurement act, we will discover a common trait in the rules involved: suspicion of the citizen and a desire not only to evaluate the outputs of her activities, but also to control and manage in detail the entire process used to achieve such outputs.

In the name of fighting corruption, managing quality or ensuring efficiency in the use of public funds, the state attempts to create the strictest rules possible to limit the powers of the bureaucrats, and to dictate in as much detail as possible how the public officials but also the citizens or firms should act.

The results are counterproductive. The resulting net of rules has two basic effects: fear or corruption. The vast

array of rules creates a disincentive for public employees to make decisions, because they risk being penalized for violations. As a result, many officials hide behind the rules and request endless series of explanations, confirmations and proofs to avoid having to make hard decisions. On the other hand, the interplay of the huge set of rules also often requires public officials to interpret the requirements, and as a result public officials with little or no real world implementation experience build up on the already burgeoning set of laws and rules with additional instructions and requirements.

Instead of evaluating the results achieved, review processes also often focus on a purely formal control of the process of filing applications, public procurement, spending or proceeding in accordance with any number of other administrative procedural rules (such as hourly timesheets for work carried out in projects, hundreds of documents required in public procurement, or correctly filed attendance report). As a result, for example, the project manager is forced to procure outdated and overpriced equipment simply because a particular machine was listed in the initial budget proposal, even though more advanced and cheaper machines came to market in the meantime.

The public procurement act severely restricts the ability to procure quality. The project managers are thus always afraid, who will decide to enter the procurement. The interpretation of the Act by public officials for example gives an advantage to providers with low quality low price products.

Similarly, the act on budgeting procedures severely restricts the usefulness of grant schemes and the ability of many institutions to make long term plans. Similarly, the act on public asset management often prevents useful partnerships between academic institutions and firms that would like to use their assets.

[The entire system deforms both its administrators, and the users who will eventually learn to adapt, and start losing interest in the quality of their outputs at the expense of fulfilling often meaningless procedural criteria.]

Cause	Solution
Extreme administrative burdens in EU funds	Debyrocratisation of EU funds
Conservative regulatory system	Reducing the administrative burden
Difficulty to procure quality in public procurement	Amending Public Procurement Act
Inability to control the quality of outputs instead of process	Stefanik stipend

Table 11. Causes and proposed solutions

Problem: Lacking support for and administrative barriers in international mobility

A clear migration strategy capable of active contribution to economic and social development is currently absent in Slovakia. An immigration policy that creates the conditions for entry of highly qualified workers, such as university students, researchers, scientists, or entrepreneurs in the areas of innovation and technology transfer, can significantly contribute to the development of work, scientific and educational environment, support the exchange of ideas and processes, and generate new job opportunities. The demographic developments in Slovakia and Europe indicate that the Slovak job market depends on foreign human capital.

Slovakia also lags behind in integration policy, which is a necessary part of a successful migration policy. It is therefore important in parallel to invest in programs supporting the integration of both short and long term migrants into the Slovak society.

Cause	Solution
Absence of a comprehensive migration policy	Creation of a comprehensive migration policy
Administrative barriers to mobility of researchers and students and select groups of foreigners (employment law issues, social support, temporary residence permit problems for foreign researchers, etc.)	Creation of a comprehensive migration policy

Table 12. Causes and proposed solutions

CONCLUSION

Minerva 2.0 has identified key barriers preventing a rapid and efficient development of knowledge economy in Slovakia. We proposed a set of 26 measures designed to overcome these barriers. In September 2011 the Slovak government set up a special Governmental council for innovation, tasked with overseeing the implementation of Minerva and coordinating future activities related to the development of a knowledge economy and the innovation ecosystem in Slovakia. In October 2011, we submitted a complex implementation plan for the 26 Minerva measures to a public notice and comment process. We expect that the implementation plan will be approved by the government in early November, thus finalizing the groundwork necessary to start the serious and critically important work of transforming Slovakia into a modern, innovation driven economy.

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REFERENCES

[1] *Academic Ranking of World Universities 2010*, www.arwu.org
[2] *Times Higher Education Ranking 2010*
[3] *Innovative Workplaces*, OECD, 2010.
[4] *Measuring Innovation*, OECD, 2010.
[5] *Higher Education to 2030*, vol. 2, OECD, 2009.
[6] *Innovation Union Scorecard*, www.proinno-europe.eu
[7] *Trend Analyses Survey*, May 2010
[8] *PISA 2009*, OECD, 2010.
[9] *How the world's most improved school systems keep getting better*, McKinsey&Company, 2010.
[10] Toner, P.: *Workforce skills and innovation,* OECD, 2011.

Online Excursions

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***Abstract*— In this article we indicate our research results realized with the first year students of the Gymnasium in Bilíkova Street in Bratislava. The analysis of selected questions from questionnaires achieved that online excursions provided the students in the classroom with the opportunity to really identify with the activities performed by their classmates in the terrain, but especially with the opportunity to search for and process the information provided by the students in the terrain.**

I. Introduction

Digital technologies bring a revolutionary change in the way people search for, process, evaluate and use information. The extent and availability of knowledge of all scientific disciplines has been growing continuously especially due to them. This is also a reason why the ability to objectively assess their quality and actual benefits is becoming a key competence that is exceptionally highly appreciated in the students.

School excursions represent a special form of instruction, involving direct interaction of the students with the environment and linking acquired theoretical knowledge with the reality. Detailed information about rules in nature, live organisms, various forms of life or processes and phenomena happening on Earth for a long time must be adequately balanced with concrete examples from life. The instruction closed in classrooms is not able to give a sense of these and substitute personal experience from a visit of a described place. On the other hand, to think out carefully, prepare, plan and finally to realize the excursion successfully with the students requires a great deal of work from the teacher. The financial side of real excursions is also not insignificant. Online excursions represent an alternative to traditional school excursions. They represent the most modern way of multimedia presentation of scientifically proved information provided in a comprehensible form, using top-class digital technologies.

II. Applied Technological Solutions

A. Adobe Connect Pro Videoconference

Real-time interactive audiovisual communication is at present among the most popular forms of communication. This form of interaction is becoming an exceptionally attractive technology due to the minimum financial costs for the procurement of necessary equipment, increasingly better quality of Internet connection as well as flat rates regardless of the amount of transferred data. A videoconference in the Adobe Connect Pro program system is virtual programmer-predefined and web-oriented environment, interconnecting several participants in a videoconference room. At present, the number of participants is limited only by the nature of license, contents specialization, ability to manage and moderate discussions and technical capacities of connected devices (equipment). An inevitable condition for the videoconference realization is a good quality Internet connection and elementary audiovisual devices (digital camera or web camera, microphone, loudspeakers). The fluency of videoconference transmission can be currently ensured also by the 3.5G/HSDPA platform devices with activated mobile Internet services. In the videoconferencing environment, the properties of individual room connections can be set so as to optimize the exchange of information (quality of sound, video, shared applications) at the current speed of Internet connection. A good connectivity level is signaled by a green light in the upper right corner of the room. The system is especially well-arranged, easy to use and features a wide range of settings capable of individual graphical user interface adjustment to videoconferencing needs and focus. It has perfectly worked-out archiving of virtual sessions with automatic conversion of files created in the MS Office programs. In addition, it provides an opportunity to record and easily edit video records created from videoconferences. The system (it) is run using permanent URL addresses copied by a user to a dialog box of preferred search engine. Having entered the specified URL address, it is necessary to enter one's identification details (name, nick, etc.) in the box under the "Enter as a Guest" text and then clink on the "Enter Room" button.

B. LMS Claroline

Claroline information system is a special program intended for the creation of educational projects, lessons and online courses. It is free software, often labeled as Open Source developed in 2001 at the Catholic University of Louvain, Belgium. At present, the system (it) is used by educational institutions in over 80 countries of the world. Since anybody can use, freely copy and disseminate the software in the same or changed version and its source code is available, it is not necessary to spend any funds on its procurement. However, the installation, activation, ensuring availability on the Internet and administration require having a very good working knowledge of the MySQL database system, PHP programming script language and Apache web server. The information system in use is at present operated and freely available on a server of the Department of Didactics in Sciences, Psychology and Pedagogy at the Faculty of Natural Sciences of the Comenius University at the web site http://www.virtual-lab.sk/claroline/. LMS Claroline consists of two functionally different but interconnected interactive environments with a simple

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graphical user interface. There are two types of displaying corresponding to these platforms. The student type is intended for individual studies, while the teacher type is intended for the preparation and management of educational projects with interactive multimedia contents. The software is controlled using several tools taking into account the type of displaying. These are in the form of hypertext links and supplemented with several easily identifiable picture icons, whose main function is making work on projects faster and well-organized.

In order to enter the system, it is necessary to know a user name and password. In case that project authors decide to publish their educational contents, also users who have not signed in may view individual parts of prepared lessons. However, they cannot create and change projects, complete their answers, multimedia, propose solutions or test the level of their knowledge by completing exercises. Only registered users who have signed in for a project are allowed to decide about the contents and influence how the information system works. These users may access projects either as their administrators (authors, tutors) or students (solvers).

The creation of educational projects is done in simple and intuitive graphical environment (interface), where the function of tools is well-described by the names of hypertext links. These include:

Project description, including elementary information on the focus and educational objectives of project.

Schedule, including planned events.

Announcements, including information of unexpected changes, current affairs, planned software outages or other events intended for users and having impact on work on a project.

Documents and references, containing a list of information resources, web sites and study materials in various digital formats.

Exercises, intended for test creation and administration. An author chooses from five elementary formats of closed (objectively scorable) questions.

Procedures and instructions, proposing the optimum learning method when studying a particular educational project.

Assignments (tasks), by means of which students gain the insight of a problem area, search for right solutions and arrive at their own conclusions. Just like in other parts of the Claroline information system, an author is not limited by an exactly defined nature of assignment or formats of attached files. Therefore it is easy to attach pictures, animation, videos or audio recordings to individual tasks, taking advantage of the e-learning environment.

While the above stated tools for controlling the system are related mainly to the creation and contents specialization of educational projects, the purpose of other (Discussion, Groups, Users, Chat and Cooperation) is ensuring interconnection between individuals (registered users). The system actively supports teamwork (group of solvers), with the communication between its members taking place in the form of online chat or created discussion forum.

A special category of work tools positioned in the left-hand part of the Claroline information system window is represented by three hypertext links at its bottom margin. Using these tools, an author decides about elementary project features (Project settings) and accessible (active or visible) list of user tools. The Statistics part is of great importance to the project administrator (author). It maps access to individual parts of educational project by the registered users as well as anonymous users in a fast, well-arranged and statistically precise manner. The project author is capable of detailed continuous checking of registered students' work and reacting immediately to objective findings or possibly making further conclusions.

III. Research Objectives, Methods and Organization

The objective of research was to find out students' interest in and opinion on realized interdisciplinary online excursions as well as use of digital technologies in instruction with an emphasis on teamwork and problem solving.

We realized in-field excursions with the students in various localities of the Devínska Kobyla Protected Landscape Area, cultural and historical monument of the Devín Castle and the Bratislava ZOO. The excursions were namely the following: "From Sandberg to Devín", "From Dúbravka to the Devín Castle" and "The Bratislava ZOO or Bilíkova for Trstená". Before the realization of the excursions with the students, six trial excursions had taken place. The functioning and adequateness of digital technologies in use as well as signal coverage of the planned routes had been tested during these excursions, since the essence of the realization of the excursions was online communication and data exchange between the classroom and the terrain. Based on findings of the trial excursions, we revised planned stops and selected suitable locations supporting the idea of the interdisciplinary excursions.

During the realization of the excursions, the students were divided into 2 groups. One group stayed in the classroom, where they had at their disposal multimedia classroom and specialized literature. The other group moved to the terrain. Both groups were divided into smaller teams of 2 or 3 members, who had to communicate and cooperate between the groups as well as with the group in the classroom, while fulfilling their tasks. The teacher assigned the students in the classroom roles within the group (e.g. data collector, moderator, cameraman, etc.), taking into account the students' interests, their knowledge, skills and capabilities. While other students were moving to the terrain, the students in the classroom were solving the tasks assigned using LMS Claroline. Each group fulfilled a specific task during the excursion. At the same time, all students worked on achieving their common objective, hence the contribution of each of them was important in order to achieve the objective. Thus teamwork, cooperation and collaboration were important.

During the realization of the individual excursions, students in the classroom changed with those in the terrain. Their roles in the terrain changed as well.

The research used questionnaire method as a measuring tool. When drafting the questionnaires, we used mainly scaling questions of our own. We gave the questionnaires to the respondents before and after the realization of the excursion. The questionnaire before the excursion

contained mostly identical questions as the questionnaire after the excursion. The questions concerned students' interest in biology, excursion topic and use of digital technologies in instruction.

The questionnaire after the excursion contained also questions concerning the assessment of the excursion itself and working with LMS Claroline. The second part of the questionnaire consisted of a simplified version of MCQ (Multimedia Communication Questionnaire), a method of communication assessment via videoconference [1].

IV. Research Results

We realized the excursions with the first year students of the Gymnasium in Bilíkova Street in Bratislava (31 students – 9 boys, 22 girls). We analyzed the questionnaires concerning the realized excursions. In the following section, we present the results of the analysis of selected questions concerning increasing the quality of instruction process and students' motivation also by means of incorporating our form of instruction in the educational process.

When analyzing the data from the questionnaires administration, we were interested in students' interest in the excursion topic supported by digital technologies (DTs) after the excursion (Figure 1).

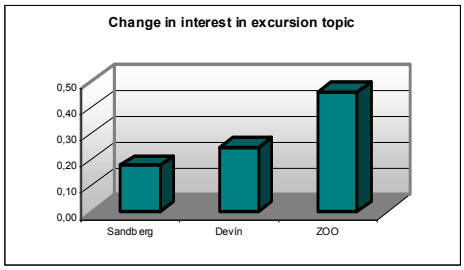

Figure 1 Comparison of the interest in the excursion topic supported by the digital technologies after the excursion.

The scale ranges from -1 to 1, with -1 meaning that students' interest decreased after the excursion. 0 means that the interest did not change and 1 means that the interest increased. As follows from the scheme, students' interest in the excursion topic increased commensurate to their participation in the excursions. The obtained results can be deemed as positive and the excursions supported by DTs as motivating the increase in students' interest in biology.

Since videoconferences are used in instruction in our country relatively rarely, we were interested in finding out students' interest in incorporating these in the educational process. We assessed the obtained data regardless of the placement into the groups and roles. The highest interest (73.32%) in incorporating the videoconferences in the instruction process was after the first excursion, which is understandable as the students participated in the above form of excursions for the first time and the experience they gained was new and interesting. After the second excursion, students' interest in incorporating the videoconferences in instruction decreased to 61.33%, which we do not see as a negative result, as the students participated in the excursion for the second time and the communication via videoconference did not seem to them so attractive as during the first excursion. In the course of this excursion, there were some problems with the picture and sound transmission in the locality, which might have resulted in the decreased students' interest to some degree. However, after the last excursion in the ZOO, students' interest in incorporating the videoconferences in instruction increased again to 66.92%. The increased interest had to do also with the excursion topic and the fact that working with the technologies had become a matter of course and the students could fully concentrate on the videoconference and instruction process.

We were also interested in finding out students' opinion on working in the Claroline information system. The assessment scale ranges from 1 to 5, with 1 meaning that working in the Claroline information system was insufficient and 5 meaning that working in the system was perfect. Working in the Claroline information system was assessed with the highest score (3.84) after the first excursion. The score of 3.84 means that working in the Claroline information system (IS) was for the students good or very good. They described the Claroline system as well-organized and relatively easy to use. Even though this was the first time that the students have worked with the system, they had no problems while completing the assignment and they learned fast how to work and orient in the system. After the second excursion, the score decreased by 0.47 to 3.37 which did not signify any marked change. The lower score could have been partly due to a higher number of assignments the students in the classroom had to solve in two hours, while the group in the terrain walked through the woods and had no signal. After the third excursion, the score of working in the system increased to 3.72, which again means good or very good score. In general, we can consider working in the Claroline IS as very good, with the system being well-organized and easy to use for the students.

During the overall analysis of the questionnaires from the individual excursions, we focused also on the scores concerning the change in the role and assignment of the students into the excursion groups as well as on comparing the interest in participation in another excursion (Schemes no. 2, 3, 4). We compared the scores between the students in the terrain and those in the classroom and between the genders. The results concerning the interest in changing the role and group and the interest in participation in another excursion range from –1 to 1, with the scores from –1 to 0 meaning disagreement to changing the role and group and a lack of interest in another excursion and the scores from 0 to 1 meaning agreement.

When comparing the scores concerning the interest in changing the role (Figure 2) within three realized excursions, we can see that all excursions in the terrain reached negative scores (Sandberg: -0.875, ZOO: -0.87, Devín: -1).

The score of -1 related to the Devín excursion means absolute disagreement to change students' roles, i.e. the students were fully satisfied with their roles. On the contrary, the scores of the students in the classroom were positive – Sandberg: 0.30, Devín: 0.14. In case of the ZOO excursion, the score was 0, meaning that the students were in essence satisfied with the roles they were assigned and some of them would have welcomed changing the roles during the excursion. If we were to examine in more

detail the interest in changing the roles between the genders, we would notice a decreasing tendency up to the negative scores in the students in the terrain. This result means that from the perspective of the attractiveness of the environment where the excursions were realized, the most interesting environment for the students was the Bratislava ZOO. Therefore the scores related to the ZOO excursion were -0.43 in the boys and 0.56 in the girls. Based on the obtained results, we can state that, regardless of the gender, the students were not much interested in changing the roles during the excursions. The result of the Sandberg excursion, where the score in the girls (0.09) was positive, could have been influenced by the fact that more of the girls were assigned the roles in the classroom and the outside environment presented via videoconference was interesting for them. However, we need to note that this was a lower positive score, which could be negligible in general.

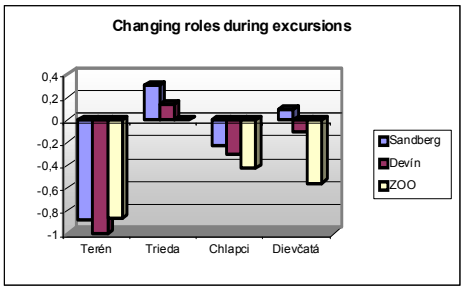

Figure 2 Comparison of the interest in changing the roles between the terrain and classroom and based on the gender within three realized Raft excursions.

Figure 3 illustrates the comparison of students' interest in changing the group from the terrain to the classroom and vice versa. The results are very similar to those in the previous scheme (Figure 2), since the assignment of the students to the roles and groups are closely interlinked.

In general, we can state that the students were satisfied with the groups and roles they were assigned. The selection and suitability of the assignment of the students to the groups and roles depended on the teacher who realized the excursion. This fact is confirmed by the above stated results of the questionnaire analysis, since the students were divided into the groups by the teacher based on their capabilities, knowledge and skills they used within the assigned roles during the excursion and videoconference.

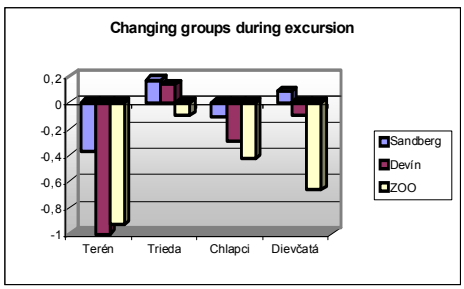

Figure 3 Comparison of the interest in changing the groups between the terrain and classroom and based on the gender within three realized Raft excursions.

Last but not least, by analyzing the questionnaire data, we wanted to find out students' interest in participating in another excursion. We assessed the data from the perspective of the assignment of the students to the terrain and classroom and from the perspective of the gender. Regardless of the gender and their assignment to the groups, all students were interested in participating in another excursion, which can be considered as a very positive result. It is notable that the scores of the interest of the students in the terrain decreased from the first excursion to the third one (Sandberg: 1, Devín: 1, ZOO: 0.73). This result could have been due to the fact that they realized the Bratislava ZOO or Bilíkova for Trstená excursion from the position of teachers for their younger schoolmates and they must have prepared for this in advance. On the contrary, the scores of the interest of the students in the classroom increased. After the last two excursions, the students in the classroom were slightly more interested in participating in another excursion (Sandberg: 0.43, Devín: 0.50, ZOO: 0.50). This result again confirmed the fact that for the students who participated in the last excursion in the roles of teachers the excursions did not seem as interesting as at the beginning.

The comparison of the interest by the gender is also notable. While in the boys, the interest in another excursion decreased from the first excursion to the third one (Sandberg: 0.56, Devín: 0.40, ZOO: 0.29), in the girls it increased (Sandberg: 0.59, Devín: 0.75, ZOO: 0.78). In general, the girls were more interested in the excursions than the boys. We assume that this result has to do with a higher information literacy and general interest in digital technologies in the boys.

V. Conclusion

As follows from the experience with using the digital technologies in the instruction process so far, online excursions provided the students in the classroom with the opportunity to really identify with the activities performed by their classmates in the terrain, but especially with the opportunity to search for and process the information provided by the students in the terrain. The also managed to meaningfully communicate and cooperate together when completing the assignments. However, a precondition for the effective cooperation of the students in the classroom and terrain is the necessity to be equipped with good quality modern technologies as well as wireless connection. In addition to obtaining new experience when working with the technologies, the students got acquainted with and learned how to work with the Claroline system, which, so to say, lead them to find the right solutions to their assignments by means of simple model task management. Working with the Claroline system is beneficial in several aspects for the students as well as teachers. It can provide them with interesting opportunities, procedures and instructions that are easily applicable in the instruction process. The students also learned how to lead the videoconference and how to behave in the process.

Thanks to the videoconference, the students could better imagine the environment their classmates in the terrain were in. They could ask specific questions concerning the assignments and thus participate in solving them. The videoconferences require quality hardware and software equipment as well as good transmission signal.

This fact may complicate the videoconference management. A negative aspect of the first two online excursions was the low quality signal, causing picture and especially sound interruptions during the videoconferences. Of course, this fact negatively impacted the overall impression of the videoconferences. In spite of that, as follows from the questionnaire analysis, it was interesting experience for the students and they would like to participate in this form of the instruction process more often.

ACKNOWLEDGEMENTS

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REFERENCES

[1] BERGIN, D.A., ANDERSON, A.H., MOLNÁR, T., BAUMGARTNER, R., MITCHELL, S., KORPER, S., CURLEY, A., ROTTMANN, J.: *Providing remote accessible field trips (RAFT): an evaluation study.* In Computers in Human Behavior. vol. 23, 2007, n. 1. pp. 192-219. ISSN 0747-5632

[2] ČIPKOVÁ, E., GREŠÁKOVÁ, J., GÁLOVÁ, T., KAROLČÍK, Š., UŠÁKOVÁ, K.: Majú videokonferencie miesto vo vyučovaní biológie? In Technológia vzdelávania. vol. 17, 2009, n. 8. pp. 3-6. ISSN 1335-003X

[3] GARDAVSKÁ, K., MOLNÁR, T., ČIPKOVÁ, E., BAUMGARTNER, R., KAROLČÍK, Š.: *Raft exkurzie vo vyučovaní biológie.* In: Zborník príspevkov z 5.celoštátnej konferencie INFOVEK. Bratislava: Ústav informácií a prognóz školstva INFOVEK, 2005. pp. 58-64. ISBN 80-7098-422-8

[4] KAROLČÍK, Š., MÁZOROVÁ, H.: *Claroline – informačný systém na správu a riadenie vzdelávacích projektov.* In: Aktuálne trendy vo vyučovaní prírodovedných predmetov. Bratislava: ŠEVT a.s., 2007. pp. 385-388. ISBN 978-80-88707-90-5

[5] KAROLČÍK, Š.: *Využitie videokonferencií vo vzdelávaní budúcnosti.* In Technológia vzdelávania, vol. 12, 2004, n. 2. pp. 12 – 15. ISSN 1335-003X.

[6] Adobe Acrobat Connect Pro. Available at: <http://www.adobe.com/products/acrobatconnectpro/webconferencing/enterprise.html> (6.9.2011)

[7] Claroline. Net About Claroline. Available at: <http://www.claroline.net/about-claroline.html> (8.9.2011)

Next generation IPTV solution for educational purposes

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***Abstract* - The aim of this work is to design an appropriate concept of IPTV for the needs of academic institutions. Based on the analysis, selected existing technologies of the components of internet television in cooperation with newly created components are transforming into a multifunctional next-generation IPTV solution with educational abilities. The result is a concentration of these functionalities into a single complex structure in the form of portal with web interface, which allows upload of high definition video content, categorization, distribution, play and assign to playlist of scheduled broadcast.**

***Keywords* – IPTV, VOD, Streaming, Wowza**

I. INTRODUCTION

The issue of streaming technology and IPTV is quite extensive and thus more and more widespread in commercial television services and also in the educational field. IPTV is a means of information delivery to the recipient in the form of video, audio or web content. This type of broadcast is transported through the network using internet protocols. Usage of IPTV is polyfunctional, but it has the largest representation in the replacement of analogue television broadcasting. Other usage includes the possibility of remote education, which is unlike video conferencing, technologically simpler option of providing one video stream to large number of recipients, but at the expense of losing interactivity from side of recipients. This fact creates a new dimension in looking at education, where barriers of distance are broken down and there is opportunity to participate in full training process through the network anywhere in the world.

IPTV adapted to educational purposes appears to be a means, which could be in the future as one of the primary sources of education, therefore, is appropriate to propose an IPTV system in the form, which meets all the requirements of learners, and it is suitable for mass usage. The aim of this work is to contribute new concept of IPTV solution for the academic environment using popular technologies in the field, with proper connection and adding newly created components.

Analysis of this work deals with mapping of existing technologies, such as: streaming, video conversion tools, web players, flash technology, HTML5 and other support tools. Work continues with creation of concept showing interconnection between selected technologies and new components necessary for the functionality required by academic institution. Implementation of the idea consists of the configuration of existing components and creation new program parts for supporting interconnection. The final part of the work evaluates the results generated by solution and the functionality of the resulting IPTV portal of new generation.

II. GOALS

The goal is to design a complex IPTV solution enabling the management, distribution, reception of video content and creation of scheduled broadcast. Work should end with the implementation of IPTV portal with user friendly interface.

III. ANALYSIS

A. Streaming

Streaming is a technology, which ensures the transfer of multimedia content over a network. It allows transmission of audio, video or even other multimedia content from sender to recipients. This technology can be used to real-time broadcasting, but also for receiving video on demand (VOD). Traditional broadcasting operates in a way where videos are broadcasted in real time in accordance with pre-planned schedule or ongoing live events from the cameras. Receiving video on demand allows recipient to choose the video content that will be transmitted at that moment.

Streaming media formats compared with conventional media formats brings many advantages. These benefits include: media content protection against piracy, controlling the flow of content, selection of allowed recipients or easy content management. For this reason, especially due to affordability, these technologies are largely appearing as an appropriate means for providing educational services through the Internet. This all brings a new dimensions and more effective teaching methods then static text and images.

Delivering of streaming media content is provided without the need to download entire files. As soon as computer starts playing the media, it also starts downloading content from the next sections from streaming server. This process is called buffering, which means that downloading content and playing the parts are going at the same time. Streaming is mostly without affecting the transmission quality, in addition to the initial buffer initialization. The aim is to provide services with streaming technologies in accordance with the limitations of network bandwidth. It is necessary to use such technology, which ensures that the recipient is receiving the data smoothly and without delay. Describing method, however, affects the quality of video playback. The

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quality of transmitted media streaming is often subject to criticism. People often compare the quality of streaming media with the quality of conventional media files and they seem inadequate. But the main and important feature of streaming media is not quality but access.

B. Resolution and codecs

Standard TV broadcast formats offer a resolution up to 720x576 pixels (SD), which means that the signal is drawn in 576 lines of 720 pixels. Minimum resolution referred to as high definition (HD) is defined as resolution of 1280x720 pixels. Maximum commonly used high-resolution live video ends on the value of 1920x1080, which is referred to as "Full HD". However there are higher resolutions for imaging and broadcasting video, which are not yet mass, because there are high costs of equipment. The more pixels can device draw, the more details can be received. Significant impact on the quality of high resolution has the way how the image is recorded and rendered on the screen. There are two types of image rendering: progressive and interlaced. Interlaced image is rendered on screen at any one time either odd or even lines. Rendering takes place so rapidly that the human eye is unable to normally capture. The smaller decline in the quality still occurs with rapid changes in the image and can cause impression of flashing. By contrast, in progressive mode, the entire area of the screen renders the image in one step for one change, so that allows tracking all the details together. The most common current formats are high definition 720p, 1080i and 1080p. This marking determines the number of lines in resolution and letter identifying way of rendering (i - interlaced, p - progressive).

Even though the quality is not the primary feature of streaming technology, it is the way, how can affect quality. When it comes to multimedia transmission through lines with high bandwidth, then can be used appropriate encoding, which ensures higher quality. When it comes to the transmission through lines with lower bandwidth, then it is possible to use the encoding, which will primarily ensures smooth playback, and then solves the issue of quality. Encoding is provided by codecs. Codec is compression algorithm, which is used to reduce the file size. Reducing of file size appears in process of transformation from conventional format to streaming media format. Programs that provide assistance for encoding with codecs are called encoders. Some encoders can encode the same source for multiple uses (depending on bandwidth). In terms of streaming technologies, here are important mainly video codecs and audio codecs. The best known are MPEG-1, MPEG-1, MPEG-2, MPEG-4, DivX, Vorbis, H.263, H.264. Each codec has ability to stream with specific amount bits per second (bit rate), which depends on the level of compression, on the resolution of the video, on the information contained in the transmission or on the number of audio channels. These codecs provide encapsulation of video content in video file format. The most common video file formats are AVI, OGG, MPG, MOV, ASF, WMV, FLV and MP4. Different codecs can be used to create various file formats, this means that file formats should not be linked only to a codec, but nevertheless there are some exceptions. The most widely used and most popular codec for HD is now H.264. This codec combines the best video quality in combination with the least requirements for the data stream. This means that it is possible to impose better and sharper video into a file on relatively small size. It has a large impact on cost savings for bandwidth and storage in the archive, unlike the previous generation's codecs. For comparison, H.264 uses the same quality recording and up to 4 times less storage capacity than standard codecs. Codec provides highly efficient use of the various kinds of applications, such as: Live TV, VOD, video conferencing, streaming and storage. It is designed to provide excellent quality in wide use (as 3G networks and mobile streaming).

C. IPTV Components

In terms of the concept of IPTV, there are several essential components needed to build IPTV solution, which provide services to end customers via the Internet. Distribution of video content to multiple packets, compression and transmission to hosts are provided by video streaming server. Conversion of media formats into a format suitable for transmission is provided by encoder. Camera is source for providing live broadcasts. The source of video on demand consists of data storage in combination with supporting tools such as web-based system for management and receiving of content (Fig. 1).

D. Expected functionality of proposed IPTV system

After introducing basics of IPTV technologies, it is appropriate to define the expected capabilities and functionality of the proposed IPTV solution for educational purposes. To make solution suitable for use in academic environment to provide educational multimedia content, it should meet the following requirements:

- Provide high definition for all services working with video content.
- Enable broadcast reception according to the schedule via a web interface.
- Realization of streaming broadcasts based on schedule.
- Include the possibility of schedule broadcast through a Web interface.
- Provide information about scheduled broadcast in the form of daily and weekly program or offer information about the current broadcast.
- Integrate environment to receive messages within broadcast in real time.
- Enable the reception from live cameras.
- Implement a live broadcast via from cameras.
- Provide reception of video on demand (VOD).
- Allow categorization of video content in VOD service.
- Allow the association name, description or other text fields for video content.
- Implement a web interface to upload new videos.
- Include automated creation of thumbnails from video.
- Include automated tool to obtain the video length.
- Allow searching for content in the VOD service.
- Offer the ability to share and spread links to the video content through social networks.

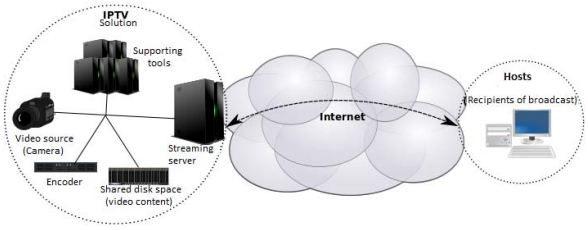

Figure 1. Concept of interconnection between mentioned IPTV components

Based on analysis of existing technologies for the needs of IPTV, it is shown that following components are suitable for use in this solution: Wowza Media Server, Stream Class Scheduler Module, Flash media encoder, FFmpeg, VLC and JWplayer.

E. Wowza Media Server

It is fully interactive server for streaming multimedia content with full support for H.264. It is Java server platform, which is also suitable for high deployment with a large number of clients in the network and with continuous operation. Wowza has wide ranging possibilities, not only as a means for streaming stored files (VOD) or live broadcast, but as a means to secure video conferencing, shared screens or games. There is also the possibility of using modules that provide control of dynamic content such as advertising or playlist. Since Wowza is based on JAVA, there is a possibility to create own modules that can be fully customized. These modules are created using an integrated environment Wowza IDE, which also offers the ability to configure and manage server activity.

Concerning security, the server provides it at a high level. It includes protection against unwanted intrusions and even restriction to capture streaming content. These features are provided through an encrypted transfer with RTMP / RTMPS protocol and special security token, which generates a strong protection against applications for recording broadcast content.

Usage of server is extensive and it is not depend of type of recipient's device. Broadcast reception is possible via the web interface, custom software applications, mobile devices or set-top box. Wowza is able to stream to all of these devices in parallel and selects the correct protocol and data flow depending on the client.

In this solution it will be utilized as the primary server for broadcasting.

F. Stream Class Scheduler Module

Additional Wowza's module provides control of streaming channels. Schedules are defined in the input file in the SMIL language. With appropriate modifications and additions, offers the following functionality: Establishment of multiple broadcast streams (channels). Possibility of creation for each channel a broadcasting schedule (playlists). For each playlist is defined date and time of playing and path to video files. For each video can be defined playback position and playback time. It also has possibility to live streaming channel in HD on the schedule in real time.

This module in combination with the Wowza server appears to be a suitable component for building new custom automated systems for creating broadcast as part of a new generation IPTV solution.

G. Flash Media Encoder

This software is built to stream live video in real time and simultaneously convert to Flash. It supports codecs H.264 and On2 VP6. The program can simultaneously live broadcast and save the broadcast to file in FLV format. This feature is useful for creating video archives in IPTV solution. Encoder has various features influencing quality of streaming beginning from selecting the encoding resolution, ending with the choice of filters to determine the bitrate. The restriction appears to be his platform compatibility, which is defined for Windows and Mac OS, but there is lack of support for control over the command line interface. The program could be controlled only through a graphical interface, which eliminates the possibility of automation.

In this solution it will be utilized for providing live broadcasts from the cameras.

H. FFmpeg

Complete multiplatform solution for recording, converting and streaming video. It can quickly convert media files between different formats. Control is provided by using the command line, but the commands are intuitive and parameters are automatically filled. It can even convert video directly from a source that is currently streamed live. It also provides additional features as resize the video using high quality filters and also directly to the live broadcast.

It will be utilized in current solution as tool for video conversion, for determination the length of video and for the creation of video thumbnails.

I. VLC

A combination of server and client designated to delivery or receive streaming media formats. VLC is built in a modular way. It means that it is possible to choose from a variety of different modules providing control of video. It has possibility of direct conversion input to the output container formats suitable for streaming. There is support for managing playlists and another advantage is the existence of extensions for Web browsers in form of VLC player which can play stream directly in browser. VLC can operate with filters in the streaming video directly like showing logo or inserting RSS. Best advantage of this tool is possibility to control every feature via the command line interface. The potential can be seen in creating automated scripts for broadcast.

In this solution it will be utilized as secondary server for broadcasting outside of the web portal (e.g. STB).

J. JWplayer

JWplayer is web based flash player with support of RTMP protocol and HTML5. It brings feature called "dynamic bitrate switching", which set the bitrate of video

dynamically according the information from user about bandwidth. This feature decides what bitrate has to be provided to best ensure the continuity and quality of play. Playback can also stop and delay live streaming, then store streaming in temporary memory and then re-launched from memory for next watching. Player supports various extensions such as publish videos directly on social networks with one control or adding information directly to the video.

JWplayer will be utilized to play broadcast and video on demand in web interface of current IPTV solution.

K. *Interconnection of components*

For the interconnection (Fig. 2) of these components is necessary to design custom components such as: web portal for access and manipulation of video content, web interface for creating the schedule, a database of videos and schedule, script for creating SMIL playlist for Wowza server, script for creating a playlist for VLC, storage of video files, live video source (video camera).

The overall solution is designed for availability all services for all roles from anywhere via the Internet. Services for administration of broadcast or VOD not depend on special programs running only at servers however, solution allows administration and configuration via the web interface in the browser. This brings consistency of solution, where almost all functions are controlled from a single comprehensive environment. Environment takes the form of a web portal with a friendly and intuitive user interface.

Overall design allows for five types (roles) of access the system: creator of live broadcasts, administrator of video content, recipient of video content via web, administrator of broadcast schedule, recipient of broadcast via software.

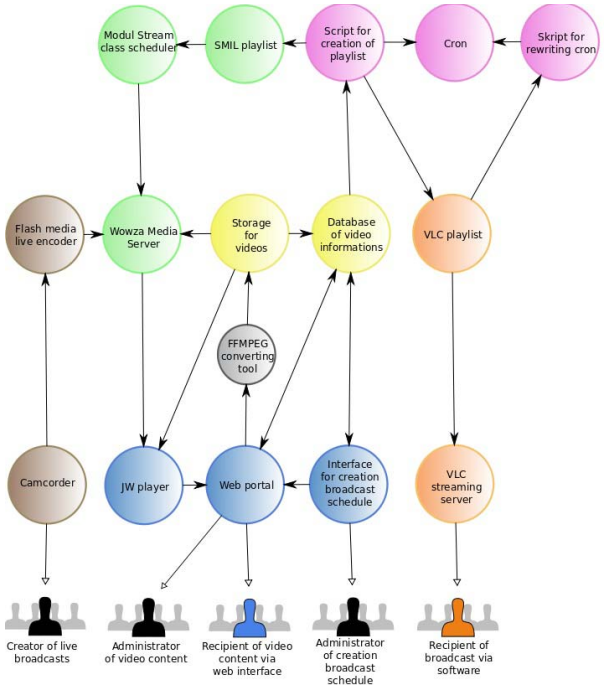

Figure 2. Design of interconnection all components in IPTV solution.

L. *The creator of live broadcasts*

This role uses live video from the camera as a source for live streaming intended recipients. He also manages encoding tool for live broadcast and through this tool also keeps a record of live broadcast to archive for next integration to VOD service.

M. *The administrator of video content*

He manages VOD section, which includes: uploading new video contents, classification to categories, nomenclature, association of textual information and thumbnail selection. He can add, edit and delete video content related to VOD section.

N. *Recipient of video content via web interface*

He has allowed watching of scheduled broadcast, live broadcasts and video on demand (VOD). He can view the schedule, search video content and share via social networks.

O. *The administrator of broadcast schedule*

This role creates and manages broadcasting schedule created from existing database of video content, where the video is assigned to the day of the week and exact time, when start to broadcast. He can also assign video from VOD section to schedule.

P. *Recipient of broadcast via software (VLC)*

He can receive scheduled broadcast outside the web interface through protocols supporting VLC streaming technology. It can be done by external software players installed in operation system in computer or set-top box.

IV. Solution And Results

Entire solution was based on an operating system of Linux (Ubuntu 10.10, Kernel 6.2.32) with installed LAMP server (a combination of Apache, MySQL and PHP). It was necessary to create a shared folder for cooperation of individual tools. In this folder are located files related to portal, configuration files and files related to creating schedule. Each section of the web portal is based on interconnection of technologies HTML, PHP and jQuery. The HTML files define placing objects on page, location of static text, dependencies to external JavaScript files or styles. JavaScript files define the characteristics and behavior of objects from the jQuery UI library. Files written in PHP furthermore ensure connection to the database and manage dynamic objects in the page. Code of Flash player (JWplayer) is located in HTML files and for improving the player look it was used modified skin.

Solution includes two files written in Bash language, which are added in system Cron. These scripts are designed to automate the operations related to create broadcast schedule. For automation it was necessary to implement two types of commands calling FFmpeg server: getting video length and getting video thumbnail. Wowza Media Server was used as the primary server for the broadcast schedule. Streaming is working through RMTP protocol by transmitting the video content from a specific application of Wowza server built for live

streaming. As a complement to server extension, it was installed Wowza Collection Module, which contains the Stream Class Scheduler module. It was important to add the server configuration component called ServerListener, which arranges loading SMIL file for organization and schedule of broadcast.

The solution includes the usage of complementary tools such as VLC and Flash Media Encoder. VLC server was used only as a secondary server operating along the Wowza Media Server for streaming to end-customers with a specific software or set-top box. Flash Media Encoder was used for live broadcasts such as software, which supports video transmission from the camera. This encoder has to run from another windows compatible hardware with connection to cameras.

Result of work is the complex web portal containing four basic sections for watching video content, management video content, upload new videos and for creating schedule of broadcast. All services are available from one web interface for all kind of roles.

A. Watching section

The first, introductory section of the portal (Fig. 3) is designed to receive scheduled broadcast. It allows to watch broadcast via web player, to show current information about ongoing stream or to appear panel for live text messages. Live text messages can be dynamically updated by administrator and are shown below video window without need for refresh page in browser. There is also a daily and weekly program schedule viewable from scrolling toolbar. Information such as name of currently streamed video is displayed in information panel above the video window.

B. Video on demand section

The second section (Fig. 4) offers video on demand (VOD) services. Content are divided in categories located at the top menu and subcategories, which showing like visual icons. After clicking on the icon pops up a list of videos belonging to that subcategory. After initialization of video playback by clicking at thumbnail, it appears window with video player containing information about video. VOD Section also contains blocks showing 5 most viewed videos and 5 latest videos. At the top of section is the search window, which is able to search video content in database after specification one or more letters. Search system automatically complete words and selects the appropriate records. Every video can be shared through an integrated link to social network (Facebook) and there is also ability to switch to full screen view.

C. Upload section

To add a new video content is specified the next section of portal called "Upload". It consists of two parts (steps). The first step is for uploading video file from the file system of currently connected user. Upon successful completion of data transfer will automatically display the second part - a step for selection thumbnail and assignment information for video (Fig. 5). In this step, thumbnail is created by changing position of slider, which updates actual thumbnail at display.

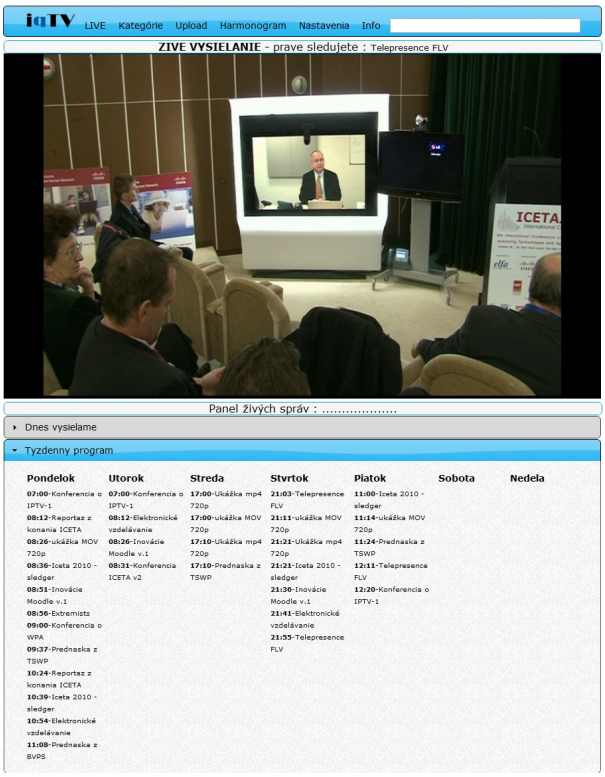

Figure 3. Screenshot of portal section for watching live broadcast and weekly program schedule.

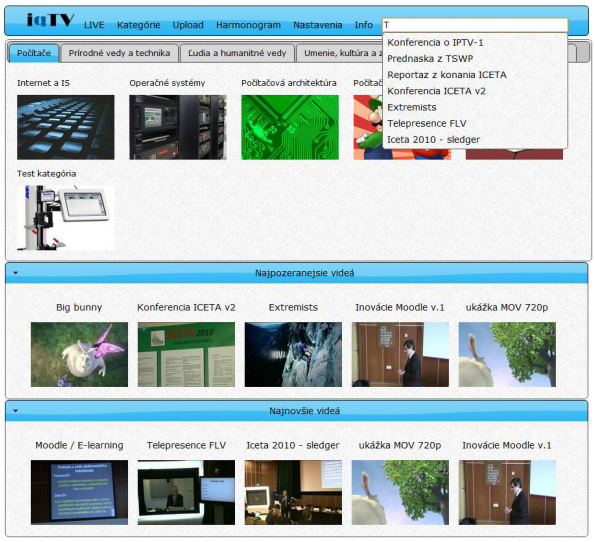

Figure 4. VOD section of portal designed for watching categorized videos.

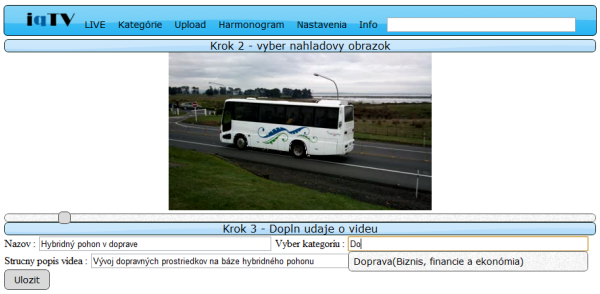

Figure 5. Choosing of thumbnail and adding information about new video.

D. Schedule section

Environment for creating broadcast schedule is implemented in a separate section (Fig. 6). It is divided into bookmarks by day of the week, where each day has the ability to add or remove blocks of the video content in exact time. Adding video is not only possible at the end or beginning of the schedule, but also in areas between existing records or it can edit the beginning of broadcasting.

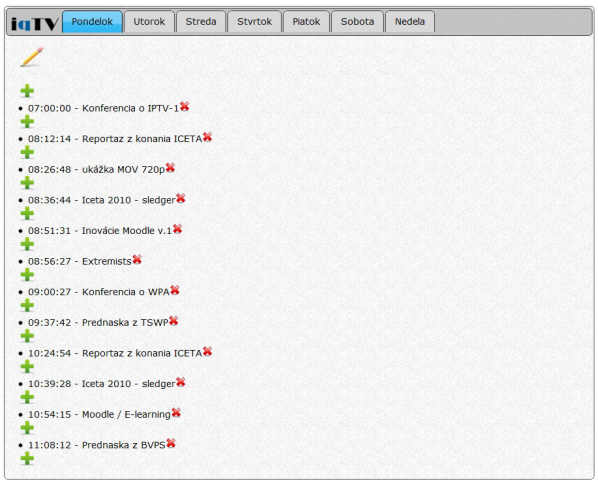

Figure 6. Environment for management broadcast schedule divided in days of week.

CONCLUSION

This work is dealing with design and implementation of comprehensive next-generation IPTV solution with the possibility to use in educational process. The design of concept was created based on an analysis of existing technologies in combination with creation custom components. Result of the work has been transformed into comprehensive and centralized system in the form of web portal with user friendly interface. The portal was built on HTML, PHP and JavaScript libraries in combination with jQuery UI. Wowza Media Server in cooperation with Flash technology was used as the primary technological solution for video broadcast. Reception of video content was provided by JWplayer, which is web based Flash player. As support tools programs like FFmpeg and Flash Media Live Encoder are used. The final result is a system which allow the reception, transmission, creation and management of video content in high definition.

From the perspective of the end recipient of services resulting web portal is designed to receive broadcast according to predefined schedule or watching video content on demand (VOD). In terms of administration of IPTV services, system carries out operations through the portal, such as adding new videos on server and creating broadcast schedule. Solution has the capability to integrate live broadcast from the videocameras encoded in real time.

In terms of functionality of the overall solution can be concluded that the system is suitable for use in the academic field as a means of education, but it is not impossible his wider usage in projects offering IPTV services outside the academic environment.

Future development of the presented system is aimed to its integration into content management system. The goal should be improvement of source codes of system in the form of modules related to CMS Drupal 7, because both systems are developed in the same programming languages. This integration will extend system functionality and usability and it will provide a central security solution covered by existing modules.

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REFERENCES

[1] G. O'Driscoll, *Next generation IPTV services and Technologies*, Hoboken: Wiley, 2008.

[2] M. Michalko, *Vývoj streamingového servera novej generácie*, Diploma Thesis, Košice: Technical University of Košice, 2005.

[3] M. Angelides and H. Agius, The handbook of MPEG applications, Chichester: Wiley, 2011.

[4] D. Cymbalák, IPTV novej generácie, Diploma Thesis, Košice: Technical University of Košice, 2011.

E-learning system and Virtual Laboratory for the study of Electronic Technologies

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***Abstract* — The paper describes the e-learning system and virtual laboratory that are intended for implementation into electrotechnology-oriented study programs. It is a short description of the main functions of the systems as well as the technologies used for the implementation.**

***Keywords* — e-learning, CAD, education, open-source, video streaming, virtual reality**

I. INTRODUCTION

The main idea of this e-learning education system is to open up the laboratories for students. Before the e-learning system was created, the students have had very short time to get familiar with the facilities in the laboratories. In most cases, they had no idea, how some technological equipment looks like and how to use them. This e-learning system show the students the real view of laboratories and on the other side, by using videos created in our laboratories, it shows step by step the way, how to use the equipment and how to do some technological procedure.

This system is a good solution of problem with the capacity of laboratories. The laboratories of our department are relatively small and there is no enough space for a larger group of students to show them the technologies.

E-learning education in the field of the technologies in electronics enables the following benefits:

- Solution of a limited capacity of the laboratory. The safety regulations allow access for the students to the laboratory only for limited number of persons. It is necessary to repeat practical demonstration of the principles and the working of technological equipment for several groups of students. The solution is on-line connection of the laboratory with e-learning system via camcorder and suitable internet interface.
- An alternative of repeated viewing of technological method without necessity of presence in the laboratory. Video records of technological processes or interactive applications illustrating the processes enable in easier way to understand all the process and interconnect the theory with praxis.
- An alternative of such illustrating demos of technologies including into the education process, which are not accessible at the education institute.

It will also save time and money in the education process, because at the theoretical lessons we don't need to show the same technological process for every group of students again and again. It is enough to create some detail videos to get the students familiar with the processes in our laboratories, what will prepare them for individual practical laboratory work.

II. STUDY PROGRAMME

Department of Technologies in Electronics of the Faculty of Electrical Engineering and Informatics offers new study program in engineering study "Advanced materials and technology in automotive electronics" from academic year 2011/2012. Main subjects of the study program are:

- Production Processes in Electronics I.
- Production Processes in Electronics II.
- Quality and Reliability Management.
- Production Technologies, Structure, Properties and Applications of Sensors.
- Design Systems in Electronics.
- Diploma Thesis I and Diploma Thesis II.

Some of them are already implemented into e-learning courses. One of the key subjects of this specialization is the subject "Design systems in electronics". Goal of the subject is to familiarize the students with top Computer Aided Design (CAD) system for design of the PCB.

Figure 1. The CAD design system - Altium Designer. [1]

Choice of Altium Designer resulted from beneficial offer for universities with potential for inclusion in project

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of educational institutes, which should result in a competition or a presentation of the students PCB designs. This form allows the students to present their skills for scientific public and also allows addressing of potential employers not only in region of Eastern Slovakia. Also the web pages of Altium Designer offer wide range of study materials, which simplify work with the design system.

To increase popularity of the study program, the practical lessons by using technological equipment are included into education process. Also the space for student is created to make functional sample of the PCB by using milling machine at the end of the Design Systems in Electronics subject study. The prepared data from the CAD system (GALAAD-Percival) control movement of the milling machine, which with the help of a special tool creates the PCB pattern of conductive paths (see Figure 2). This "dry" method of the PCB production was selected because of rate of the sample production and contrary to "wet" way of the PCB production there is no need to liquidate the chemical waste (etching solution).

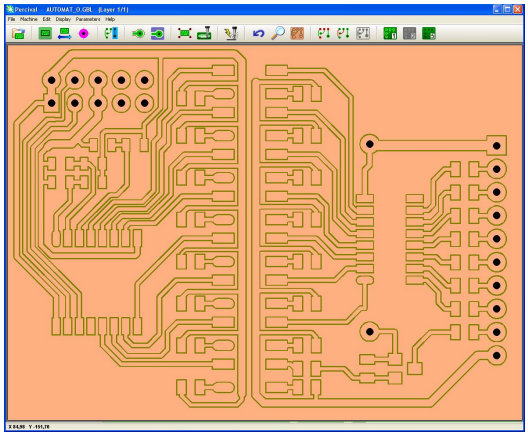

Figure 2. GALAAD Integrated CAD-CAM-CNC software – module Percival. [2]

Another e-learning supported subject is the Production Technologies, Structure, Properties and Applications of Sensors. It is focused on basic knowledge as well as for acquaintance with new progressive trends in the area of materials and technologies for sensors production. The subject acquaints the students with materials used at sensors production, with partitioning, principles (see Figure 3) and characteristics of sensors, with mainly used technologies: semiconductor, thin- and thick-film, as well as new technologies used in production of MEMS systems

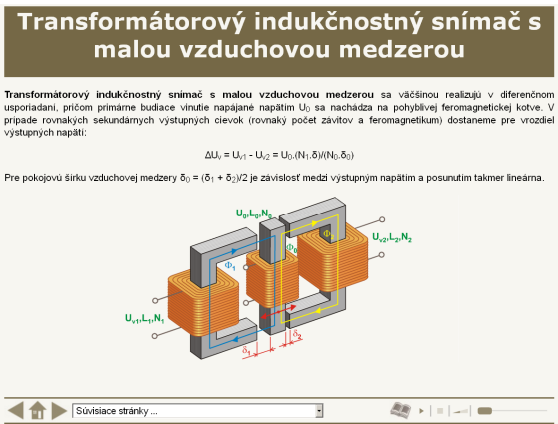

Figure 3. View to the sensors principles screenshot from e-learning module under the Moodle platform

for sensors used in temperature, mechanical, geometric, magnetic and chemical parameters sensing as well as of biosensors.

III. VIRTUAL TOUR

A. Main functions

The best way, how to prepare the students for individual work in the laboratories is to introduce them every piece of available equipment before they really go to the laboratories. At the practical lessons, the student should make real laboratory exercises instead of searching the applicable equipment or tool, or finding the laboratory, where the needed equipment is located in. For this reason, we have created a real life virtual tour from our laboratories.

From each laboratory at our department we have created a 360° panoramic picture, by using adequate technological equipment to eliminate optical defects. In the e-learning system, these panoramas are viewed by a special open-source web applet, which allows us to create some clickable areas in the panoramic picture. By clicking on these areas, the user can start some specific action, e.g. start a video, open some web page or go to other part of the virtual tour.

The user can look around in the laboratory by using the buttons (see Figure 4), or through automatic tour, as well as he can zoom to some selected part of the virtual tour.

Figure 4. Virtual tour with standard buttons

In the virtual tours, the interesting objects are highlighted by different color (see Figure 5). By clicking on them the user can open the card of the equipment, on

Figure 5. Highlighted clickable equipment

which he can find some basic information about the selected technological equipment (in which technological process can be used the selected equipment, link to its user manual), links to the video files and animations related to selected object and other.

B. *Technologies used for creating the virtual tour*

For creating of detail photos we have used a DSLR camera with a tripod and a special, self-made panoramic head, by which we have created digital photos without any optical defects. The panoramic head allowed us to create every photo from the same position (the camera is turning around of its optical centre), what is very important precondition for successful automatic sticking of the created photos. If we don`t use a panoramic head, it is impossible to stick the photos without getting some optical defects because of parallaxes (see Figure 6).

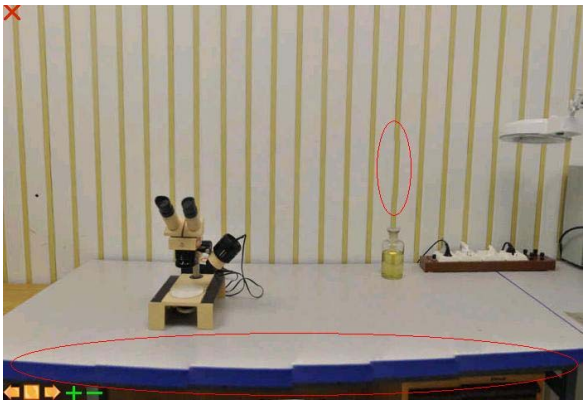

Figure 6. Optical defects because of parallax in a panorama made from photos taken without the panoramatic head

For sticking the photos to a panorama we have used the open-source program, Hugin. This software can be used for automatic sticking of the photos, what can save a lot of time. In case of some problems during the sticking, the user can help the program to find some control points to get better result.

The panoramas are showed by an open source java applet, PTViewer. This applet can view panorama pictures in web pages. The applet have a lot of useful features, e.g. creating of clickable areas, adjusting the size of the viewing window, zooming, manual or automatic turning around, high resolution parts of the panorama, etc.

IV. OTHER PARTS OF THE E-LEARNING SYSTEM

A. *Live video*

The second fundamental parts of the e-learning system are video files and video streaming. Existing internet connection in every laboratory allows us to create live online video streams from the laboratories about the technological procedures made at our department.

For capturing the videos, we have available two types of cameras. One IP camera with maximal resolution of 1.3 Mega-pixels at the frame rate of 15 frames per second (30 fps at resolution of 0.8 Mpix) and a classical digital camcorder connected to a notebook by a TV-card.

The first camera with fixed 4 mm lens is eligible for creating of some overview videos about the procedures made in the laboratories, while the second camera, if it is used with a tripod, can create detail, close-up videos. The video from the camcorder is streamed to the LAN by the open-source video streaming program, VLC.

Every stream will be collected by a multimedia server. This server will collect the video streams from every camera as well as from the computers connected to different technological equipment (climatic chamber, electronic microscope, etc.) and computers used for lectures (PowerPoint presentations with audio records from the lecture).

This server will use the collected multimedia materials as sources for streaming them to the local network as well as to the internet. This step is very important, because the cameras can not serve more connections and on the other side, the server will be the only computer visible from the internet. This is a big security advantage.

The server will stream multimedia in two ways (see Figure 7). In our local network there will be available a multicast stream, which need less system resources, but is reachable for everybody located in our network. To the internet, we will send unicast stream (as known as "on demand stream") – it will be available only for authorized persons. This method is less effective than multicasts, because it request more bandwidth and creates more load on the server, but it is not possible to stream multicasts out of our network (most of internet providers are blocking them).

The multimedia server will also create a copy from every stream for future use. This will generate us a multimedia archive, which will be used in education process in the future. This archive will be available for students and will be searchable by different criteria.

All component of the streaming server will be implemented on open-source technologies. For streaming the screen of the computers will be used application called VLC. This program will be also used for streaming the content from the multimedia server.

On the client side, the stream will be viewed by a java applet, alternatively by the vlc-plugin for internet browser. The first one seems to be a better choice, because it only need a java runtime environment, which can be found on most computers (if not, the most of internet browsers have built in function to install it), while the vlc must be installed manually (it requires more technical knowledge from the users).

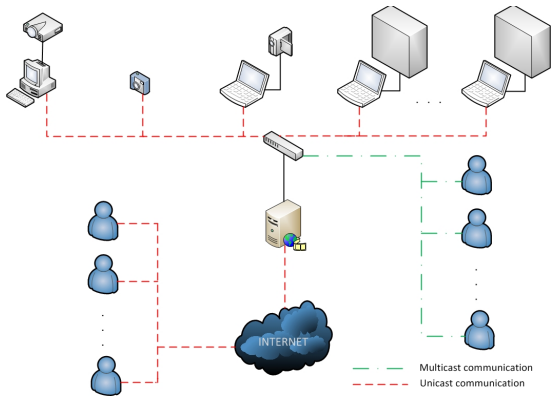

Figure 7. Communication system architecture

B. *Video archive*

A very important part of the e-learning system is a video archive, what is made up from videos created in our laboratories. These videos bring the students detail view to the technological processes made in the laboratories.

The videos in the archive can be sorted by different criteria, e.g. by technological process, by equipment, by laboratory, etc.

C. *Flash animations*

The third part of the e-learning system is flash animation support, which allows illustrating the technological processes. The animations are linked to the appropriate technological equipment as well as to the steps of some technological procedure. The animations in the system can be sorted by different criteria, too.

The preparation of animated components is realized by using the Adobe Flash CS4. From this platform the components are implemented into the study materials. The mentioned software was selected behalf various reasons. In particular it provides tools for producing of interactive animations, which allows creating of objects corresponding to real processes. In the following there is the possibility of increased interactivity with the user, what is scarcely possible to achieve with utilization of classic scripting tools.

In the Figure 8 and Figure 9 is static view to two of created Adobe Flash CS4 animations which illustrate the semiconductor materials physics and manufacturing in particular steps. The pictures show mainly structure of all pages for modules with color scheme, header on the top of the page and control/navigation toolbar for navigation across full course on the bottom of the page.

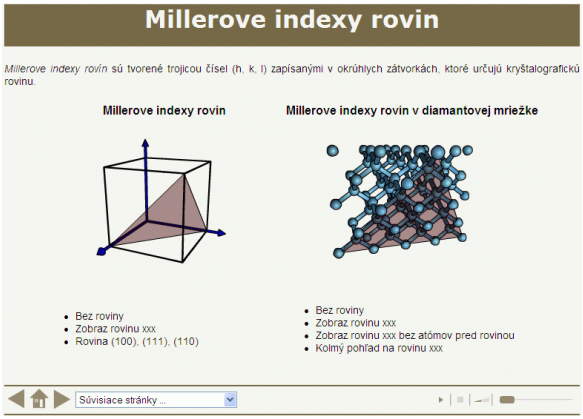

Figure 8. View to the Adobe Flash CS4 animated component embedded in e-learning module about semiconductor materials physics

The navigation toolbar has the standard form with buttons for previously browsed page, for home, for next recommended page, list of related pages, and toolbar for playing audio files (from left to right side). The on-line e-learning module is only in Slovak language recently.

Figure 9. View to the Adobe Flash CS4 animated component embedded in e-learning module about semiconductor materials processing

CONCLUSION

A number of study modules at the Department of Technologies in Electronics were created in the frame of e-learning support of education. Evaluated e-learning system and virtual laboratory solves the capacity limitations of laboratories at our department and it already helps our students to get familiar with the laboratories and their equipments as well as with the technological processes made at our department. Continuous preparation and practical utilization of animated components under Adobe Flash platform is in progress for educational process with the scope of technologies used in microelectronic industry. The described system has good preconditions to be a useful e-learning system that will help the students to study more effective and attractive.

ACKNOWLEDGMENT

This paper was elaborated in the frame of the KEGA project No.: 3/7117/09.

REFERENCES

[1] Ready to Teach Grant Program, United States Department of Education, http://www2.ed.gov/programs/readyteach/2005awards.html

[2] Adobe Flash Professional, http://www.adobe.com/products/flash/whatisflash/

[3] Cisco virtuálna učebňa pre stredné a vysoké školy, 2006, http://servis.inet.sk/clanok/3757-cisco-virtualna-ucebna-pre-stredne-a-vysoke-skoly

[4] CAD software: http://www.altium.com

[5] CAD software: http://www.galaad.net

[6] PTViewer Documentation: http://webuser.fh-furtwangen.de/~dersch/PTVJ/doc.html

[7] Hugin: http://hugin.sourceforge.net/

[8] VLC: http://www.videolan.org/vlc/

IT Industrial Certifications in Practice

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***Abstract*—IT industrial certifications have become successful response to the extremely fast and constant changes in the industry of information and communication technologies. The certifications are widely accepted within the industry as industry standards for assessment of particular technical skills and knowledge. Speaking of local conditions in Slovakia, concept of industrial certification needs to put more emphasis and raise awareness. This paper presents general overview on IT certifications. It defines and summarises the types and categories of IT certifications, describes certification process and relation of certification to general training process. Benefits of certification for individuals and organisations are also outlined. Furthermore, the paper presents one of the most globally successful IT certification – Microsoft Office Specialist and finally it shares local practical experiences with IT certifications in Slovakia.**

I. Introduction

Information and communication technologies (ICT) have become very significant part of modern civilisation. We encounter them in every-day routine, both in personal life and work. Thanks to these technologies, new market segments, areas of business and career paths have being established requiring skilled employees – from standard information workers to highly experienced IT professionals. New technologies emerge continuously and replace the previous ones. The ability to use and utilise current ICT determines our future professional career and job opportunities.

The growth and use of ICT and the resulting demand for workers with specialized skills have placed a considerable pressure on traditional educational systems to provide a qualified and sustainable ICT workforce. In response to constant changes and advances in ICT and slow response from traditional education, ICT industry has established industrial certification as preferred way to assess and measure skills and knowledge. **Certification** (of skills and competences) **results from voluntary evaluation process whereby an individual's knowledge and/or skill in a particular area of interest are validated against a set of predetermined skills requirements** e.g. skills standards by means of an objective assessment [1].

In 1989, Novell created the first IT certification in response to a lack of trained individuals to support their mission critical tasks and the inability to turn to the traditional educational system for a trained supply of workers [2].

Industrial certification plays an important role in today's ICT industry mostly because of the following reasons:

- Industrial certification represents **standardised method** for assessment of knowledge and skills in specialised area.
- Certification schemes **map directly the current technologies with defined set of skills required to operate these technologies.**
- Certifications are **globally recognised** across the particular industry.

Certification process comprises all activities by which a certification body establishes that a person fulfils specified competence requirements. This process is standardised and acknowledged all across the particular industry.

In other words, holding an IT industrial certificate means that we are qualified enough to operate the certain ICT and this qualification is globally recognised in the ICT industry. Two different individuals (from different parts of the world) holding the same certain industry certificate have the same level of skills and knowledge. Particularly, the momentum of standardisation and globalisation give industrial certification a great deal of importance.

It is necessary to mention the difference between certificate and industry certificate. The first one usually means the documents acknowledging attendance in an instructor-led course or any form of formal training while the industry certificate is perceived as a credential, a result of an objective assessment procedure running by the third party, that an individual met the performance specifications delineated in job profiles recognised by industry stakeholders.

II. Categorisation of IT Certification

There are many possible ways how to categorise the available industrial certifications in IT. To bring up some main categories:

- **Vendor orientation:**
  - Vendor neutral: certification is not aligned to a particular producer (company) but technology as itself (for example CompTIA)

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  - Vendor centric (vendor specific): certification is aligned and directly managed by a particular technology producer (e.g. Microsoft Office Specialist)
- **Expertise level**: entry, intermediate, advanced (expert)
- **ICT skills level**
  - Certifications for digital literacy: assess the very basic ICT skills (e.g. IC^3, ICDL)
  - Certifications for end-users (e.g. Microsoft Office Specialist): the ones who need to have their ICT competences assessed and certified as a tool to do a job which is primarily related to a non-ICT-sector of industry
  - Certifications for IT professionals (e.g. Cisco Certified Voice Professional): this address specialists, who want to demonstrate a specific knowledge or competence in their core activity ICT field
- **Product vs. technology oriented**
  - Product oriented certification: certification focuses on a particular product and/or its version (e.g. Microsoft Windows 7)
  - Technology oriented certification focuses on the particular technology, rather than on a specified product/version
- **Certification complexity**
  - One-exam certification: to acquire the industrial certificate an individual must pass only one single certification exam (e.g. Cisco Certified Network Associate)
  - Chain certification: an individual must successfully pass more than one exam, or have successfully completed lower level exam (e.g. Check Point Certified Security Engineer)
- **Language of certification**
  - Single language: the certification is available only in one language
  - Multi-language (localised): exams are available in many language

  Usually, each globally recognised IT certification is provided at least in English language. Many of them are available in the main world language (e.g. Chinese, Spanish, Russian, French etc.)
- **Result evaluation**
  - Automatic non-human evaluation: test is evaluated by a testing system, without any input needed from a proctor
  - Human based evaluation: test must be evaluated by proctor (administrator) manually
- **Delivery method**
  - Computer based exam: exam is delivered via specialised testing software
  - Semi-computer based exam: during an exam a computer is used but part of exam is delivered traditionally (e.g. by pen&paper)
  - Pen&Paper based exam
  - Oral exam
  - Web-based testing: a candidate does not have to take an exam in the testing centre, but he can do it via internet and online
- **Area of technology**: digital literacy, desktop applications, networking, operation and server Systems, development tools, process management, virtualisation, security, etc.

Each type of certification has its advantages and disadvantages. The current trend is to provide the certification exams by using computer based testing, preferably as web-based (online testing).

III. Organisation of IT Certification

The standard organisation model of IT certification involves several important stakeholders (see Fig. 1).

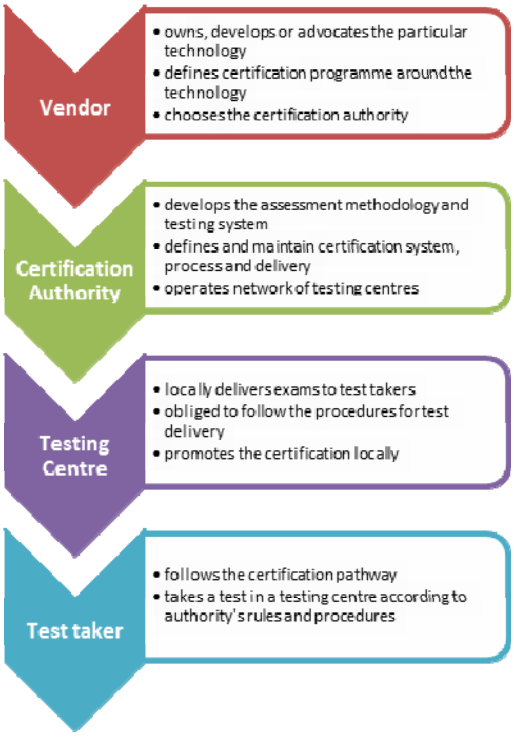

Figure 1. Organisation of IT Certification

1. **Vendor (or sponsor)**: usually IT company which owns, develops and supports particular ICT (meaning hardware, software or process). As such technology is standardised and widely accepted by the industry, the company establishes and maintains a certification programme for this technology. All of the globally leading ICT companies have developed their own certification programmes (e.g. Microsoft, Cisco, IBM, Oracle etc.). Also non-commercial organisation might become a vendor for IT certification – for example CompTIA which is a non-profit trade association advancing global interests of IT professionals and companies.
2. **Certification Authority**: is responsible for developing, maintenance and updating the assessment methods for particular vendor's certification programme, certification system, process and delivery. The authority also manages and carries out the certification (in terms of process

and delivery). It must meet at least two basic requirements:

a. Deliver an assessment based on industry knowledge, independent from training courses or course providers.

b. Grant a time-limited credential to anyone who meets the assessment standards.

The certification authority co-operates closely with one or many vendors (as its clients) while still being neutral from them. Certification authority usually operates internationally or globally. Currently there are few main global certification authorities: Certiport, Prometric and Pearson VUE. There are also other authorities which may operate more locally and in more specialised segment of IT industry.

3. **Testing centre** is a local company or institution (e.g. school) which is responsible for particular delivery of certification exams in its geographical area of operation. Testing centre must meet the certification authority's technical, organisation, process and personal requirements to ensure that the certification process has its defined quality.
4. **Test taker** (or candidate) is a person who wishes to take an exam (test).

Earning certification means successfully passing one or several certification exams. Rules how an exam is passed are defined by the certification authority.

Delivery process is carried out by a testing centre and is (mostly) computer based. Exam is provided by a testing system (local or online application). Test taker is required to follow exam's instructions, tasks and questions while being passively monitored by test administrator (or proctor). Test taker's actions or/and results are evaluated automatically by testing system or manually by the administrator and is provided with results. Results are in the form of test report with final overall number of points.

Certification programme is usually structured in terms of defined set of skills to achieve, level and dependencies among exams and certification. The programme is usually graphically displayed in form of a certification map to let test takers have better and more convenient overview of the whole programme. An example of certification map can be seen in Fig. 2.

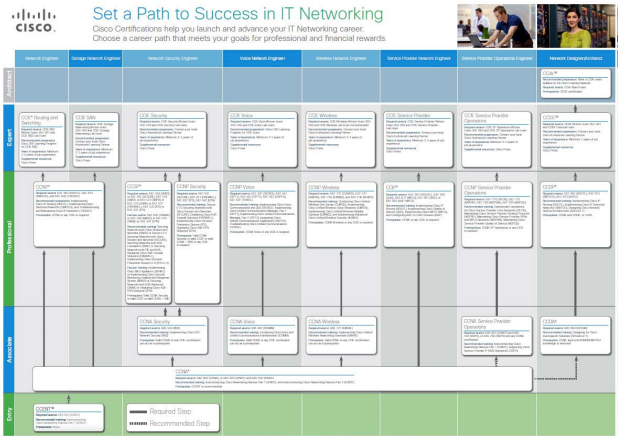

Figure 2. Map of Cisco certifications [3]

Recertification is an important indicator to IT professionals and their employers, ensuring that the certification holder has kept up with current trends in the technology. Valid certifications may be renewed indefinitely, but without timely renewal, certifications expire or become inactive. To keep certifications current, individuals should recertify by advancing to the next level of certification or passing the designated recertification exam(s). [4]

IV. Place of Certification in Training Process

General training process in ICT industry involves industrial certification as its natural part. In fact, certification is necessary output of the whole process.

The process consists of several stages (see Fig. 3):

1. **Definition of set of skills and standards**
2. **Main training process** (diagnostic test – training – test)
3. **Industrial certification**

The whole process is framed by education (meant as formal education system) and work experience or vocational training.

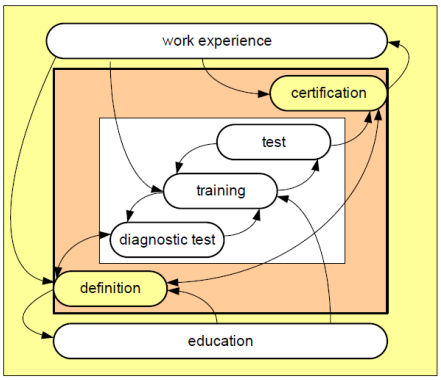

Figure 3. Place of certification in learning process [5]

There are several stakeholders participating in the whole training process: state or government (through its educational system), training providers (as bodies delivering the particular training), certification authorities, and employers as definers of wanted qualifications.

Certification in this model can be seen also as a feedback on the main training process. Successful participant should go to take an exam fully prepared and fully aware of its skills, strengths and weaknesses.

Work experience determines a required set of skills which need to be covered through the training process. There should be a direct link from work experience to definition stage.

The whole training process is obviously revolving, which means that when finishing one stage, more advanced stage is awaiting. This ladder finally leads to the highest possible qualification in the industry.

V. How to Get Prepared?

In the previous section we outlined a place of certification in general training process. However, how to get prepared for a certification exam? Which are the best how to succeed?

Study obviously depends on the exam's difficulty. The length of the study might take from 1 week to several years. Practice show that the most optimal way for study is to combine several possibilities:

1. **Books** are relatively cheap, often come with great practice questions and are specifically geared towards the exams.
2. **Online certification forums** are a great way to interact with a community of people who are interested in the certification.
3. **Take a training class** (or preparation course). Whether it is online or in a classroom, training offers a hands-on way to learn the material. It is more costly, but it is usually a guaranteed way to pass exams.
4. **Online Practice Tests.** Some are free and others cost money, but all of them will get a test taker in the test-taking mode. Most online practice exams run from 20€ to 70€ and provide a solid way to test the knowledge and readiness.
5. **Visit vendor sites** to find a link that point to education or certification to learn everything about the certification process as well as recommended training and study tools. They often offer exam guides and practice questions free for the taking. [6]
6. **Practical experience** is a critical way how to acquire the knowledge as well as context of the technology. It is necessary to understand that one learns not just to pass the exam but to gain more knowledge, skills and move up in his qualification. Therefore a practical experience is essential in this process.

VI. Why Should I Aim for Certification?

The five main reasons and motivation for an individual in Europe to pursue e-skills certification are (in order of decreasing importance):

1. increase credibility
2. assessment of knowledge
3. preparation for a new position
4. increase personal productivity
5. fulfilment of job requirements

The main reasons in other parts of the world are slightly different. For example, ICT workers in North America go for certification in order to be up-to-date with new technologies [7].

Critical momentum for certification comes with focus on students and young people and their chances to be successful at their future career. Personal agencies in the United States of America claim that young people with IT certificate are twice as likely to be placed in the labour market, 50% more likely to be hired on full time and get average 10-15% higher pay than non-certified workers [8].

Survey [9] carried out in Slovakia and Czech Republic in 2009 shows that 81% of respondents think that IT certification is important for further career.

VII. Benefits for Organisations to Have Certified Employees

Certified professionals give an organization a competitive advantage. They can help increase customer satisfaction, reduce operational costs, and push service to a higher level, which translates into an excellent return on investment.

The survey of more than 1 100 IT managers responsible for more than 3000 teams [10] shows that certified teams are 28% more productive. Almost 750 of managers believe that certifications are important to team performance and 66% of managers believe that certifications improve the level of service and support offered to IT customers. A concentration of certifications in a team is clearly linked to improved capability and team performance.

Other study of 14 000 end-users certified on Microsoft Office Specialist conducted [11] shows that employees with a (Microsoft Office Specialist) certification contribute to more knowledgeable and productive working environment:

- 62% of certified employees say that they are more productive than their non-certified co-workers.
- 85% of supervisors say Microsoft Office Specialist certified employees are more productive because of their certification.
- Nearly 70% of certified employees say they make a greater contribution to their employers with certification.
- 60% of certified employees say they take on more complex or difficult assignments after certifying.

Certification also supports the job satisfaction and loyalty. Employees who go through the process of (Microsoft Office Specialist) certification are more likely to gain the skills that enable them to feel more confidence and satisfaction by progressing in their employment. By providing certification opportunities, managers retain the skilled and dedicated employees that are essential to an organization's success.

VIII. Overview of the Most Popular IT Certifications in the World

The following list comprises the most popular IT certifications in 2011 (listed in alphabetical order) [12]:

- Certified Information Security Manager (CISM)
- Certified Information Systems Auditor (CISA)
- Checkpoint CCSA NGX certification
- Checkpoint CCSE NGX Certification
- Cisco Certified Internetwork Expert (CCIE)
- Cisco Certified Security Professional (CCSP)
- GIAC Security Audit Essentials
- Microsoft Certified Technology Specialist (MCTS)
- Red Hat Certified Architect (RHCA)
- vmware Certified Professional

All of the above mentioned certifications are for IT professionals – senior and expert specialists in particular areas of ICT. What is possible to see from the list is that there are few categories in which these popular certifications belong: networking, security, operating systems, virtualisation and key Microsoft technologies.

On the other hand, we can name 10 entry-level certifications which are designed to support the start of career in ICT industry [13]:

1. CompTia A+
2. Microsoft Certified Professional
3. Microsoft Certified Desktop Service Technician
4. CompTia Security+

5. Certified Internet Webmaster (CIW) Associate
6. Sun Certified Java Programmer
7. Cisco Certified Networking Associate
8. Microsoft Office Specialist
9. MySQL
10. Graphics & Internet Certifications

IX. Microsoft Office Specialist – Globally Recognised Certification for IT Worker

Microsoft Office Specialist (MOS) is the credential required by academic and business institutions, recognized globally as the premier credential chosen by individuals seeking to validate their knowledge, skills and abilities relating to the Microsoft Office systems.

MOS is independent confirmation of an individual's mastery of Microsoft Office programs via realistic, performance-based tests. It is the only credential of its kind provided by Microsoft. The certification programme was created and launched by Certiport in 1997.

The MOS certification is structured in 3 bottom-up levels providing a continuum for skills qualification and validation:

Microsoft Office Specialist (Core Certification) validates skills with the Microsoft Office 2010 suite. Exams are available on Microsoft Office 2010 products:

1. Microsoft Word 2010
2. Microsoft Excel 2010
3. Microsoft PowerPoint 2010
4. Microsoft Access 2010
5. Microsoft Outlook 2010
6. Microsoft Project 2010
7. Microsoft SharePoint 2010

Microsoft Office Expert validates advanced skills in specific Microsoft Office applications.
Gaining the credential requires that a candidate pass either of these exams:

1. Word 2010 Expert
2. Excel 2010 Expert

Microsoft Office Master denotes fluency in several important Microsoft Office applications. To achieve this designation, a candidate must pass four exams: Word 2010 Expert, Excel 2010 Expert and PowerPoint 2010 and either Outlook 2010 or Access 2010.

Test questions are based upon "objectives or tasks" defined by more than 400 Subject Matter Experts in 20 countries, correspond to real world tasks, written by professional item writers and validated by professional psychometricians.

For **academic institutions** the MOS certification:

- Provides relevant, state-of-the-art validation of course offerings
- Embeds digital literacy within programs and curricula
- Offers comprehensive, cost-effective way to give students the opportunity to develop skills necessary for academic work and required by businesses
- Enhances instructor development programs

The certification also:

- Enables students to progress through coursework and curriculum with greater ease and efficiency
- Empowers students with individual differentiation, setting them apart from others pursuing future academic admissions and employment
- Delivers real-world, recognized credentials—MOS is a distinguished credential for students when applying for jobs, demonstrating workplace readiness

The exam delivery system is very straightforward and is standardised:

1. Candidates take exam in proctored environment of test centre. The exam takes 45 minutes.
2. Candidates receive printed score results. Results are then uploaded to global candidate database.
3. Certiport delivers certificate to passing candidates.
4. Candidates can view their online Digital Transcripts through website www.certiport.com.

Certiport prepares individuals with current and relevant digital skills and credentials for the competitive global workforce. These solutions are delivered worldwide and include Certiport Internet and Computing Core Certification (IC³), Microsoft Office Specialist, Microsoft Technology Associate, Adobe Certified Associate, CompTIA Strata Fundamentals of IT Technology and the iCritical Thinking™ Certification.

Certiport delivers exams in 141 countries and 24 languages. Roughly, 106 000 exams are administered monthly through a network of more than 10 000 Certiport Centers worldwide. Totally, Certiport has delivered more than 7.6 million exams worldwide.

X. Practical Experience with IT Certifications in Training Institute elfa

Training Institute elfa is the leading training provider for IT trainings and certification in Slovakia. The company provides client with high-quality training activities, industrial certification, complex project management for educational projects and e-learning and e-content services.

The institute runs, since 2004, the testing centres for all major certification authorities: Certiport, ECDL, Prometric, Pearson VUE. Thanks to this unique combination it is ready to accommodate clients with most of available IT certifications. Annual number of certified candidates is approx. 1000 individuals, mostly IT professionals. The most popular exams are Cisco Certified Networking Associate, Microsoft Certified Professional and vmware Certified Professional.

IT certification has been included in the standard training process for particular sets of trainings: mostly trainings on Microsoft Office (with ECDL and/or MOS certifications) or trainings on Cisco networking technologies (CCNA certification). Certification was part of several training projects focusing on increasing employability of long-term unemployed people. The complex training process included diagnostic (entrance) testing, instructor-lead training, e-learning up to

certification itself. Also the back loop from certification to training is important dimension for increasing the quality of training services – as new certifications are introduced, this momentum launches process of adjusting existing/development new training content to align to the change certification programme.

The comfort of testing delivery is currently being substantially extended by implementing online registration system for certification exams. This system helps candidates to register for an exam at the Training Institute elfa and is standardised for exams tested via different certification authorities.

Training Institute elfa operates as *Certiport Authorised Solution Provider* for Slovakia and Czech Republic as well as *Microsoft Academic Solution Provider* for these two countries. It has broad experience and contact with academic sector – thanks to involvement in *Microsoft IT Academy Program*, *Cisco Networking Academy Program* and also thanks to various academic projects (e.g. national projects *Modernization of Education at the Primary Schools*, or *Modernization of Education at the Secondary Schools*).

Conclusion

This paper presents general issues on phenomenon of IT certifications. It introduces the concept, necessity and structure of certification followed by discussing benefits and advantages of certification for individuals as well as for companies and organisations. Further, Microsoft Office Specialist as an exemplary IT certification is introduced giving also short introduction of Certiport and Training Institute elfa.

We believe that this paper outlines and gives good first impression on very important part of IT training industry – which is certification. We think that IT certifications have become essential part in the IT industry.

We also feel that these topics need further and more detailed examinations which might be very promising starting point for further papers or articles.

References

[1] CompTIA, *The Situation and the Role Of E-Skills Industry Certification In Europe*. 2004, pp. 18-19

[2] Ziob, L. L., *Time is flying: 10 years of IT certifications.* Certification Magazine, 2005

[3] Cisco Systems, *Cisco Certificate Certifications Career Poster*. https://learningnetwork.cisco.com/docs/DOC-11573, visited 10 October 2011

[4] Príbelová, P., *Non Academic Education Based on Industrial Certification*, Conference ICETA 2010, Slovakia

[5] eSCC: *eSkills Certification Consortium. The Situation and the Role of e-Skills Industry Certification in Europe*, Thessalonica, Greece, 2004, pp. 37

[6] Reuscher D., *How To Study for a Certification Exam*. http://certification.about.com/od/entrylevelcertification1/ht/howtostudy.htm, visited 10 October 2011

[7] eSCC: *eSkills Certification Consortium. The Situation and the Role of e-Skills Industry Certification in Europe*, Thessalonica, Greece, 2004, pp. 33

[8] D.Hansen. *Measurable Outcomes through Industry Certifications*. Certiport. 2008, pp. 8

[9] Belko P., *Survey on IT Trainings and Certifications*, 2009, http://belko.blog.sme.sk/c/224402/Vysledky-prieskumu-o-IT-vzdelavani-a-certifikacii.html, last visited 10 October 2011

[10] IDC, *Impact of Training on Network Administration: Certification Leads to Operational Productivity*, November 2009

[11] Certiport, *Making the Difference*, 2011

[12] Nanospeck, *Top IT Certifications for 2011 - An Overview*, http://nanospeck.hubpages.com/hub/Top-IT-Certifications-For-2011-Best-In-Demand, visited 10 October 2011

[13] Reuscher D., *Top 10 Certifications to Begin Your IT Career*, http://certification.about.com/od/entrylevelcertification1/tp/topbeginner.htm, visited 10 October 2011

Using Tag Clouds to Support the Comparison of Qualifications, Résumés and Job Profiles

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***Abstract*—The labor market is today characterized by a marked competitiveness. The ability to accurately choose the right education and training paths leading to the acquisition of the right competences required for a given job position, as well as the capability to properly select human resources based on precise job requirements are becoming more and more key factors to success. Nevertheless, the comparison of education opportunities generally requires a manual analysis of huge qualification descriptions and course syllabi, whereas staff selection (or job seeking activities) often relies on non-automated processes mainly based on an extensive check of applicants' curriculum vitae (or of possible job offers). The above tasks are extremely time consuming and, given the large amount of information to be considered, they also risk to provide unsatisfactory results. In this paper, the above issues are addressed in the perspective of semantic technologies. In particular, a web-based application is presented, which exploits ontological descriptions and tag cloud-based visualization strategies to generate a direct representation of the overlap between learners' needs and existing education and training paths, as well as between job seekers' profiles and company requirements. This way, potential users are provided with an effective support for matching job and study offers with corresponding demands.**

I. Introduction

In recent years, learners' and workers' mobility became a relevant topic in the European legislation. In fact, in order to enhance the comparability of qualifications across Europe and increase the competitiveness of the European labor market, several initiatives, such as the Bologna Process [1] and the Bruges-Copenhagen Process [2] have been undertaken. Nevertheless, while in higher education mobility between Universities and recognition of prior learning are almost a praxis, a fully inclusive society where learners' and workers' learning outcomes could be accumulated in a comprehensive lifelong learning perspective is still under construction.

One of the main obstacles to the implementation of the above vision was represented by the shortage of tools capable of fully supporting the readability, transferability and comparability of qualifications. In 2008, the European Parliament and the Council took a first step to address such needs by establishing the European Qualification Framework (EQF) [3], a common reference system acting as a translation device to make qualifications readable and understandable across different European countries and systems.

According to the EQF guidelines, the above objectives could be reached by adopting a rigorous classification of all qualifications based on eight reference levels, and by precisely defining the semantics of associated learning outcomes (expressed in terms of knowledge, skills and competences), thus opening the way for the creation of a shared understanding in the lifelong learning domain.

However, the creation of a European-wide framework is only part of a more complex process: in fact, even though the EQF defines a shared format for cataloguing and expressing qualifications, concrete achievements of individuals (either resulting from formal, non-formal or informal education and training processes) have to be expressed with a syntax-independent formalism capable of overcoming linguistic and cultural (i.e., semantics) barriers.

In this paper we introduce the LO-MATCH platform (http://www.lo-match.polito.it), a web-based tool that is being implemented in the context of the MATCH "Informal and non-formal competences matching devise for migrants employability and active citizenship" project. The platform relies on semantic technologies to tackle heterogeneity issues in the descriptions of qualifications/résumés and labor market's needs due to the use of non-shared vocabularies. Moreover, it exploits a tag cloud-based visualization technique to quickly depict aspects to be considered in the mobility and job seeking phases. Specifically, tag cloud properties, like font size and distance from the center of the cloud, are used to provide an immediate overview of the main characteristics of a given qualification with respect to specific learner's needs, as well as to highlight key job seeker's attitudes with respect to a particular job offer (both from the job seeker's and the employer's points of view).

The rest of the paper is organized as follows. In Section II, research activities focused on the construction of tag clouds are presented, together with several application possibilities. Section III illustrates the main idea behind the designed platform, by discussing the steps required for creating the repository the overall approach is built upon, by analyzing the proposed tag cloud-based presentation strategy and by finally presenting the envisaged usage scenarios. Finally, Section IV provides conclusions and shows open research directions to be possibly investigated in the future.

II. Background

With the evolution of Web 2.0 and the opportunity for content providers and users to add metadata to published contents, a number of techniques have been developed to

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support users in performing search tasks, categorizing data and navigating the ever growing amount of information. In the above scenario, tag clouds started to be used as an attractive means for providing, at a first glance, a summary of the background information hidden into websites, blogs, and various online communities (like, for instance, Flickr, Delicious, etc.).

Basically, a tag cloud exploits effective information visualization techniques to present a visual overview of textual data, often corresponding to a set of tags. In a tag cloud, the font size used for drawing the tag is generally linked to importance (or frequency) of the tag itself. Originally, in tag clouds information was displayed using a rectangular line-by-line layout. Recently, the research community started studying the impact of other visual parameters on the attractiveness of tag cloud-based representations. As a matter of example, in [4] color information was included to visualize the actuality of tags. In [5], the impact of font weight and other text features on the execution of various user tasks was evaluated. A number of works dealt with the optimization of tag clouds layout. In [6], the constraint of rectangular layouts was removed, and a graph-based structure was used to visualize relations between tags. In [7], a circular layout was proposed, and tag relevance was displayed by exploiting tag size as well as tag distance from the center of the cloud. In [8], tag placement based on similarity was exploited, by clustering similar tags in the cloud based on co-occurrence. A different approach was taken in [9], where the basic tag cloud properties were considered with regard to aesthetic criteria.

Meanwhile, several studies were presented where the actual support provided by tag cloud-based representations to the execution of traditional tasks carried out on the web was analyzed in both qualitative and quantitative terms. Though in some contexts (e.g., information mining) more trivial visualization techniques appeared to outperform tag clouds, in other scenarios encompassing visual browsing, multi-dimensional visualization, impression formation and information recognition/matching, tag cloud-based representations proved to be capable of providing a valuable support [5][10].

Indeed, also according to the outcomes of the above studies, advancements on this topic will definitely benefit of practical study cases demonstrating the effectiveness of tag cloud-based techniques in concrete application scenarios like the one presented in this work.

III. Matchmaking and Tag Clouds

As said above, in order to help learners and job seekers in the identification of education/training or working opportunities better fulfilling their needs or expectations (in terms of missing or matching knowledge, skills and competences, respectively), as well as to support companies in the selection of the right candidates for a given job position, in the framework of the MATCH project the LO-MATCH semantic platform was designed.

The proposed web tool exploits an ontology, i.e., an *explicit specifications of a conceptualization*, as defined in [11], to describe qualifications/curriculum vitae and occupational profiles (expressing labor market's needs) collected in the LO-MATCH knowledge base. In order to make the above elements comparable, descriptions have been structured in terms of learning outcomes according to the EQF indications, and each learning outcome has been annotated (i.e. marked with one or more tags) in a manual or semi-automatic way by making reference to concepts defined in the ontology.

In the ontology, concepts are linked to other concepts by means of relations, which mostly belong to the subsumption category. Subsumption relations contribute to the creation of the overall hierarchy of concepts/tags (taxonomy) that allows the platform to deal with learning outcomes expressed at different levels of details, thus improving comparison results.

Collected information is then exploited to draw a cloud-based representation of a qualification (when the learning dimension is took into account), or of job applicant's characteristics/company's requirements (when the job seeking/hiring domains are considered). In the following, the methodology for the construction of the knowledge base, as well as the approach for the generation of the tag cloud-based representation are presented by making reference to specific usage scenarios.

A. Construction of the Knowledge Base

In order to ease the insertion of relevant information into the knowledge base, a semi-automatic mapping procedure has been created. In a nutshell, the functioning of such a tool could be summarized as follows: when the user specifies a new learning outcome (e.g., as part of a qualification/résumé or of an occupational profile), the system automatically detects and suggests him or her the relevant concepts that could be linked to each word in the newly introduced element.

In order to perform this task, the tool exploits the Wordnet repository [12], an English thesaurus collecting lexical and semantic relations among terms. When the user chooses a particular concept for annotating a given word of the selected learning outcome, the lexical/ semantic relations in the ontology are also recorded (together with related concepts). When a particular word is not found in the repository, the user can specify another term he or she may consider related somehow to the initial one (e.g., it could be more generic, more specific, it may share the same definition, etc.). Concepts associated to the new term can then be used to annotate the selected learning outcome word. This way, the initial scope of the ontology is extended, and new annotations could possibly rely on a more complete set of concepts and relations.

For each concept linked to a given learning outcome, a value of mastery/importance has to be provided (when the user considers some concepts more important than others). The difference between degree of mastery and importance is linked to the particular kind of end user working on the platform: in fact, when an education and training actor (or a job applicant) inserts a qualification (or curriculum vitae) in the knowledge base, he or she has to specify a degree of mastery, whereas when a company (or a learner determined to find a training path fulfilling his needs) is inserting its requirements, it has to specify a degree of importance. In other words, the degree of mastery refers to the (education/training or job) offer perspective of the matchmaking process, whereas the degree of importance is related to the demand side.

As a matter of example, Fig. 1 shows the graphical interface that allows companies and learners to specify

Figure 1. Insertion of a new concept in the set of company's/learner's requirement.

new requirements together with the associated degree of importance. In particular, the degree of importance could assume the following values: *low*, *medium-low*, *medium*, *medium-high*, *high*.

B. *Generation of the Tag Cloud-based Representation*

Concepts stored in the knowledge base and their degree of importance/mastery are used to draw a cloud-based representation of a) the characteristics of the qualification better satisfying learner's requirements, b) the features of a job seeker's curriculum vitae better matching company's requirements, c) the main aspects of a company's working profile that could better valorize job position applicant's abilities. In the present implementation, the importance i of a concept is represented by means of the font size (with larger fonts indicating more relevant concepts), whereas the degree of mastery m is linked to the distance from the center of the cloud (e.g., for applicants with an exhaustive knowledge of the requested subjects, a compact tag cloud would be generated). This representation allows to simultaneously display both the dimensions of the matchmaking problem, i.e., learner's requirements and learning outcomes associated with a particular qualification, company's needs and job seeker's characteristics, etc. Thus, even non-skilled users/operators could easily see why a given matching has been obtained.

TABLE I.
DEGREE OF MASTERY FOR KNOWLEDGE ELEMENTS EXPRESSED BY TWO JOB SEEKERS APPLYING FOR A SHOP ASSISTANT POSITION AND IMPORTANCE IN THE COMPANY'S PERSPECTIVE

Knowledge element (concept)	First applicant	Second applicant	Company
Product	high	high	high
Selling techniques	-	-	high
Negotiation techniques	-	high	-
Customer identification techniques	-	high	-
Internal procedures and policies	low	medium-high	medium
Health and safety rules	medium	low	medium
ICT	medium-high	low	low
English	medium-high	low	low
Exposition techniques	low	medium-high	low
Organization techniques	-	-	low
Team working	low	medium-high	low
Basic sales legislation	low	low	low
Inventory techniques	-	-	low
Quality	low	medium-low	low
Analysis techniques	-	-	low

When focusing on the point of view of a learner looking for a qualification capable of filling his or her learning outcome gaps (or on the perspective of an employer searching a worker to hire), the font size used for drawing the tags is determined by sorting learner's (company's) needs in a descending order based on importance i and by calculating the relative weight of a given concept with respect to the complete set of requirements. Then, concept coordinates are computed as $x = r\cos(\theta)$ and $y = r\sin(\theta)$. In such expressions, r is defined as $R(1 - m + D)/D$, where R is the maximum radius of the cloud, m is the degree of mastery, D is the number of possible values in the grading scale used for i and m, and θ is a random angle. More details on the above steps are reported in [13].

The toy example reported in Table 1, presenting the requirements of a sample job position and the curricula of two possible applicants, should help to clarify the process. In particular, if values from 1 (*low*) to 5 (*high*) are used for measuring i and m (i.e., $D = 5$), concepts *product* and *selling techniques* would represent the 20% of the knowledge requested by the company; then, *internal procedures and policies* and *health and safety rules* would represent the 12%; finally, the remaining concepts would be assigned the 4%. The font size would be determined by attributing a different value to the various percentage ranges, e.g., font size 10 for values between zero and 5%, etc. Then, assuming for instance $R = 500$ and choosing a random angle $\theta = 335°$, the *ICT* tag identified for the first applicant would be positioned at $x = 181$ and $y = -84$ (assuming the center of the cloud in $x = 0$ and $y = 0$).

Fig. 2 and Fig. 3 show the tag clouds for the curricula of the two applicants, based on the taxonomy reported in Fig. 4: since the company identified as a crucial aspect the knowledge of *product* and *selling techniques*, related tags are drawn with a large font, followed by the knowledge of *internal procedures and policies* and *health and safety rules*, and by several minor knowledge elements. The first applicant (Fig. 2) has a high knowledge of the *product*, a medium-high knowledge of *English* and *ICT*, and a medium knowledge of *health and safety rules*. However, he or she has a low, or null, knowledge of other aspects of the work. Thus, only four elements are drawn close to the center of the cloud, whereas missing knowledge elements,

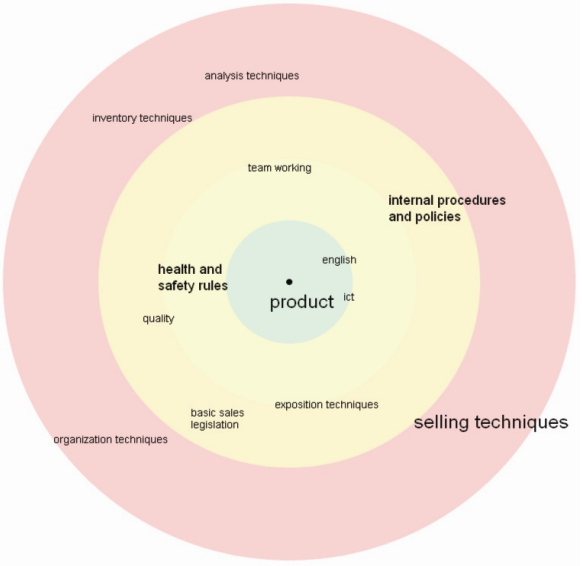

Figure 2. Tag cloud-based representation of the first applicant's curriculum vitae in the company's perspective.

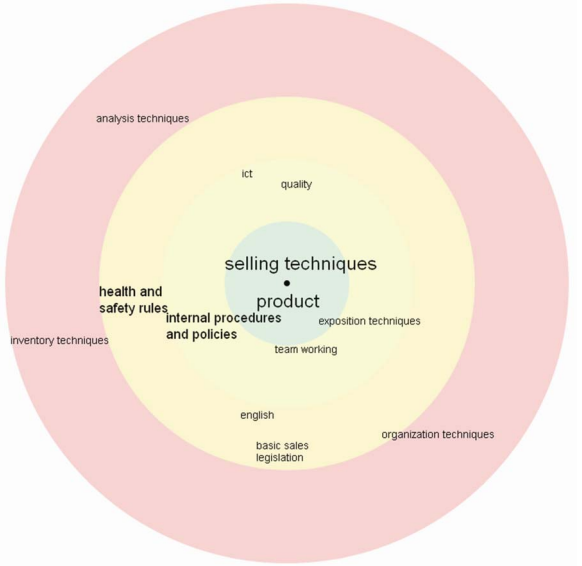

Figure 3. Tag cloud-based representation of the second applicant's curriculum vitae in the company's perspective.

like *selling techniques*, are placed on the external area (thus underlying their lack). In turn, the second applicant (Fig. 3) already had some experience in the field; in fact, he or she shows a high knowledge of *product*, *negotiation techniques* and *customer identification techniques*, a medium-high knowledge of several other aspects, and a low knowledge of remaining elements. Since, according to the ontology, *negotiation* and *customer identification techniques* are subsumed by the *selling techniques* concept, he or she possesses also a significant knowledge of *selling techniques*. Hence, the *product*, *selling techniques* and *internal procedures and policies* tags appear in the central area, thus making the second applicant the best (or, at least, a good) candidate for the given job.

The above examples analyze matchmaking results from the company's point of view. Nonetheless, comparable investigations could be carried out, for instance, from the perspective of job seekers, who are interested in finding

Figure 4. Portion of the ontology of interest for the tag clouds exemplified in Fig. 2 and Fig. 3.

companies that could recognize their abilities.

The interface designed to this purpose is depicted in Fig. 5 (still making reference to the example above). On the left hand side, a tag cloud shows how much the concepts expressed in the second applicant's résumé are made explicit in the description of the employers' requirements. In this case, in order to shift the focus on the applicant, the tag cloud is created by inverting *i* and *m* (i.e., by linking the font size and the distance from the center of the cloud to the degree of importance and the degree of mastery, respectively). On the right hand side, hints about those aspects the job seeker should address further in order to increase his or her opportunities of getting recruited by the given company are displayed: in this case, the candidate should improve his knowledge of *health and safety rules* (by raising it up to a medium level), and acquire some knowledge of *organization techniques*, *inventory techniques* and *analysis techniques*.

The job applicant could then exploit the devised platform to find a qualification (or part of it) providing the missing knowledge. In this case, the system would automatically record his requirements together with the needed level of importance, and would trigger the matchmaking with a demand input rather than with an offer description. It is worth remarking that, even though for sake of simplicity the examples above only dealt with knowledge elements, in the MATCH project the described approach is actually used to draft a comprehensive tag cloud-based representation of EQF compliant learning outcomes, with knowledge elements linked to action verbs and to context information in order to express skills and competences, respectively (according to [14]).

IV. Conclusion and Future Works

In this paper, a tag cloud-based application supporting qualifications comparison and job matchmaking is presented. The proposed tool relies on a knowledge base containing qualifications, curriculum vitae and job profiles expressed in terms of knowledge, skills and competences. Information stored in the knowledge base have been annotated by exploiting an ontology initially based on the

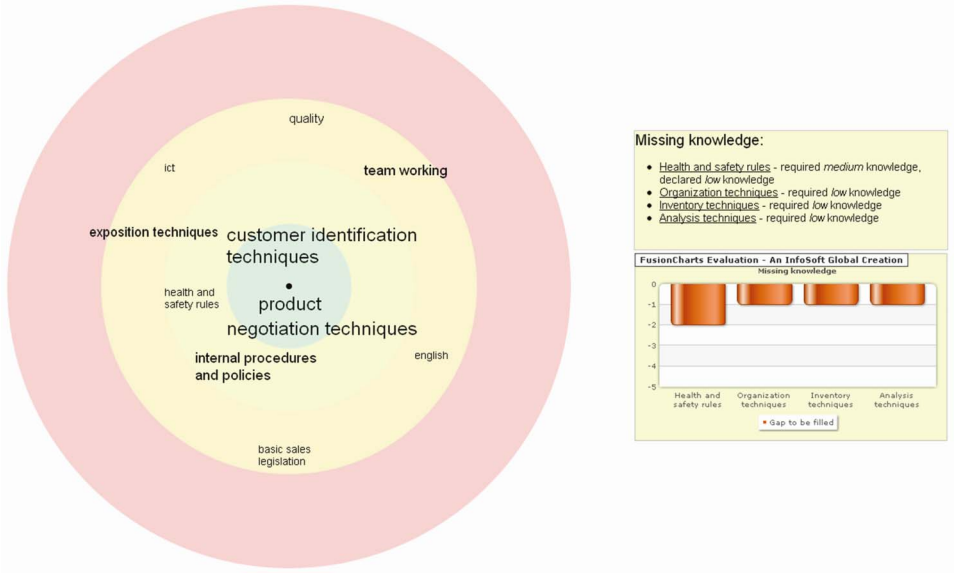

Figure 5. Tag cloud letting the second applicant (whose knowledge is reported in Table 1) compare his or her expertise with company's requirements.

Wordnet database, which has been later extended by the users, where needed. Target users could be either learners, job seekers or companies. In fact, learners could exploit the platform to easily and effectively find qualifications fulfilling their education and training needs. Job seekers could use the tool to find the job offers better matching their abilities. Finally, through the platform, companies could get an immediate overview of the expertise of candidates applying for a given job position. On the one hand, thanks to the use of a uniform notation for describing aspects which may be expressed in different terms and at different levels of details by the various actors, the proposed tool aims at overcoming lexical and semantic barriers between education, training and working offers and demands. Moreover, by exploiting trivial properties of tag cloud-based representations (like font size and distance of tags from the center of the cloud), an immediate overview of aspects of interest resulting from the comparison can be provided to heterogeneous users.

Future works will be devoted, on the one side, at considering additional factors in the construction of the tag cloud-based representation. On the other side, efforts will be devoted to extend available features, e.g., by introducing the possibility for the learners to identify training courses providing learning outcomes associated with a particular qualification or by letting the platform suggest competences and learning modules to be considered by the companies for on-the-job continuous training. Finally, the presented methodology will be extended to other sectors, and subjective tests will be performed with the aim at evaluating the usability and acceptability of the designed platform as well as to quantify its added value with respect to other tools for comparison and matchmaking like, for instance, text-based facilitators.

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REFERENCES

[1] "Bologna Declaration Communiqué of the Meeting of European Ministers in charge of Higher Education (19 May 2001)".

[2] "Declaration of the European Ministers of Vocational Education and Training, and the European Commission, Convened in Copenhagen on 29 and 30 November 2002, on Enhanced European Cooperation in Vocational Education and Training - The Copenhagen Declaration".

[3] "Recommendation of the European Parliament and of the Council of 23 April 2008 on the Establishment of the European Qualifications Framework for Lifelong Learning".

[4] B.Y.L. Luo, T. Hentrich, B.M. Good, M.D. Wilkinson, "Tag Clouds for Summarizing Web Results", in *Proc. of the 16th Int. Conf. on World Wide Web*, pp. 1203–1204, 2007.

[5] A.W. Rivadeneira, D.M. Gruen, M.J. Muller, D.R. Millen, "Getting Our Head in the Clouds: Toward Evaluation Studies of Tag Clouds", in *Proc. of the SIGCHI Conf. on Human Factors in Computing Systems*, pp. 995–998, 2007.

[6] B. Shaw, "Utilizing Folksonomy: Similarity Metadata from the del.icio.us System", Project Proposal, December 2005.

[7] K. Bielenberg, M. Zacher, "Groups in Social Software: Utilizing Tagging to Integrate Individual Contexts for Social Navigation", Master's Thesis, University of Bremen, 2005.

[8] I. Ad, K. Thiel, M.R. Berthold, "Distance Aware Tag Clouds", in *Proc. of the IEEE Conf. on Systems Man and Cybernetics*, pp. 2316–2322, 2010.

[9] F.B. Vigas, M. Wattenberg, J. Feinberg, "Partecipatory Visualization with Wordle" in *IEEE Transactions on Visualization and Computer Graphics*, vol. 15, no. 6, 2009.

[10] Y. Hassan-Montero, V. Herrero-Solana, "Improving Tag-Clouds as Visual Information Retrieval Interfaces", in *Proc. of the Int. Conf. on Multidisciplinary Information Sciences and Technologies,* 2006.

[11] T.R. Gruber, "Toward Principles for the Design of Ontologies Used for Knowledge Sharing," *Int'l J. Human-Computer Studies*, vol. 43, no. 5/6, pp. 907–928, 1995.

[12] C. Fellbaum, "WordNet: An Electronic Lexical Database". MIT Press, 1998.

[13] V. Gatteschi, F. Lamberti, A. Sanna, C. Demartini, "A Semantic Matchmaking System for Job Recruitment", in *Proc. of the 10th International Conference on Knowledge Management and Knowledge Technologies*, pp. 50–59, 2010.

[14] B. Pernici, P. Locatelli, C. Marinoni, "The eCCO System: An eCompetence Management Tool Based on Semantic Networks," in *Proc. of the Workshop on Ontology Content and Evaluation in Enterprise*, pp. 1088–1099, 2006.

Platform of Educational Process Support for the Internet Technology Area

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Teaching internet technology allows the usage of a wide range of approaches and tools. The platform mentioned in this paper seeks to integrate these resources and also offers the possibility of direct testing of subject matter. Its involvement in educational process has been done, and still is, within the subject the Development of Internet Applications. It turned out that the usage of practical and interactive examples to test students' knowledge has positive results. So, the formed software platform is a base tool that brings more interactivity and student involvement during the teaching lessons.

I. INTRODUCTION

University subjects teaching brings a wide range of options and approaches that are often affected mainly by the type of these subjects, theirs content, form of teaching tools, etc. The tools and approaches used for some kind of teaching are usually focused on the interpretation of the theory which is often problematically linked with the practical involvement of students already during the initial phase of some topic presentation. Ensuring sufficient interactivity is thus neglected at the expense of theory, supported by the classical concept of interpretation in the form of lectures. Although students have an opportunity to check and verify the information obtained during lectures based on laboratory or practical exercises trainings, they are often confronted with the practical usage of gained knowledge through their employment.

This state then penalizes the students themselves, as well as efficiency and quality of their work for employer. The educational process should give them sufficient knowledge base for practice, which is unavailable for the most of the students. But also offers of ways how to solve common problems during practice should be a part of their education. So, the E-learning approach is often use, because it can include theory, practice, research or can cover sophisticated teaching process based on innovative and effective approaches.

A specific area in terms of education and available tools are technological based subjects. For these subjects or lectures, emphasis placed on practical usage of knowledge is crucial [1]. The perception of relation between theory and practice is one of the major outputs of the educational process. The students should be able not only to identify and describe issues concerned with a given topic, but should be able to apply and use their knowledge in real deployments.

This article discusses the possibilities of promoting the learning process of technical subject focused on web development and Internet applications. The developed educational platform is used as the main tool for mentioned purposes. The mission of this platform is the above-mentioned support of relation between theory and real-world experiences.

II. CONCEPT OF TEACHING PLATFORM

The platform to teach Internet technology and web application development goes a step further from this point of view. Its aim is to provide teachers and students new opportunities for interactive teaching and testing the acquired knowledge. It focuses mainly on demonstrating the technology discussed in the examples and exercises that seek to verify the practical knowledge and skills gained from lectures and materials. Everything is placed into a real environment of Internet or Web technologies [2].

The main advantage, compared to traditional/non-interactive way of teaching, is direct usage of a test server even during at the lectures. This opens up new possibilities for presentation of information and results, which are applicable by students during their test. The interactive lessons extended by all important educational components are provided based on this platform. Also the students' feedback of their activities during the lecture is achieved.

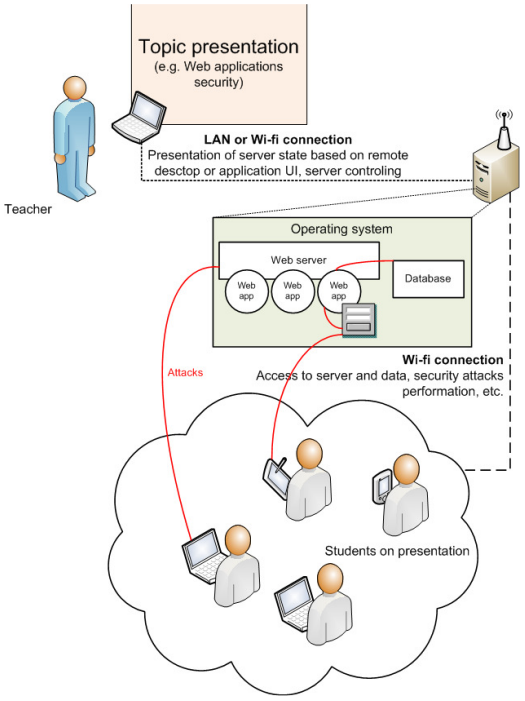

Figure 1. Utilization of our platform directly within the teaching of internet security topic

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The Figure 1 illustrates a general concept of mentioned platform even during the topic presentation. The security of web applications is a case study topic at this moment. The hardware devices – server is the basis for the platform operation. It can be accessed by teacher as well as students. These two roles need to have different access rules and interfaces for obtaining interactivity from/to our platform. The administration interface is provided for teacher. Based on this, all the settings via an intuitive user interface can be changed as well as the activity can be monitored. Local Wi-fi network is primary used to connect to the device. Based on this connection the students use the platform to test their knowledge to pass the tasks and perform the examples.

III. EDUCATIONAL PLATFORM FOR WEB APPLICATION DEVELOPMENT

The basic idea of the general concept of educational platform is based on direct interactivity between teacher and students. The area of Internet technology and Web development offers rich possibilities for implementing the relations between theory and practice. In essence, the theory plays more supportive role in this area, mainly for supporting the standardization of approaches and results. But just the application of knowledge, approaches and technologies in a practical deployment is a fundamental element for teaching of this area.

A. Educational platform integration to the teaching process

This chapter tries to describe basic process how the concept of our platform should be used during the lectures. The server (laptop, special portable device, etc.) with installed platform software needs to be started to use the platform in the classroom. This device will be act as a test server during the lesson. Its job is to offer platform interface and capture and evaluation of all user requirements and related responses. Also the presentation of results and monitored values is its role. The students can connect to this server via local established wireless network that is operated only for those specific purposes. The teacher can select the topic and its materials using the administration interface. This selection opens the lesson for students and also configures the server as needed. Everything takes place only within an easy user interface and therefore it is no need for a deeper impact into the application or platform itself. The platform may also include materials required for a given topic presentation

Figure 2. Zotac ZBOX HD-ID11 as an example of suitable server (source: www.zotac.com)

and lectures which is prepared by teacher. The overall concept of the platform integration and usage was shown above in Figure 1.

It is possible to see all the functionality and relations of the concept. Also the ways to communicate with the server is depicted. Specifically, the scheme covers issue of web application security, which is used as a case study example to illustrate the ability of our platform. It is also important, that we use "special" kind of hardware equipment which is prepared and installed only for the purposes of the platform. In our case, we just use simple Atom mini PC, which fulfill all requirements as portability, MS Windows compatible hardware, sufficient performance, etc. The fact, that this type of hardware is

```
!url::attack=yeso::
!url::attack=yes::
ip::192.168.1.1-192.168.1.2::
ip::192.168.1.6::
session::fine=true::
session::fine2=true::
post::sme=yes::
!post::soxme=yeser::
```

Figure 3. Příklad kofiguračního souboru

not equipped by LCD display is mostly advantage because of price and portability. The access to the server environment and software of platform can be established by remote desktop access from any standard laptop within range. The example of this suitable piece of hardware can be Zotac ZBOX HD-ID11 see Figure 2.

B. The platform architecture

The administration interface is a one of the basic parts of the platform. It is available only for teacher. Thanks to this administration, the teacher can change the contents of each lesson, choose the current lesson materials, tasks and examples, see and check the tests results, has a full control over the tests operation and restore the whole platform to its original state (prepare it for next lesson) Particular lectures are stored as an application modules. These modules are divided into several functional units which communicate between each other and which are linked to platform core.

The first part of architecture is a set of *configuration files*. These configurations include the variables needed to connect the module to the application itself, the interface addresses and port numbers for the teacher and students access. In addition, they also defined the location of each part of the module. For simplicity and usability with the widest area of technology the configuration files are written in the form of a standard text document. The form of their content is based on own syntax and grammar that is chosen to allow simple definition of test case requirements. An example configuration file is shown in Figure 3. In this case, the sense of this configuration file example can be unclear, but it is necessary to bear in mind that the close relation between the configuration and a given lesson is covered within this setting.

Another important part of each module is associated with *teaching materials*. This is the content of lectures and exercises. They are not being exclusively focused on textual materials, but also the animations and another multimedia data can formed the content. Of course, the

scripts and application codes illustrates the topic in practice are stored there.

Next part is an interface module for each user especially students. Mostly it is formed by *simple applications* running inside a Web browser. The interface for each module can have its own graphic design easily changeable using styles. Teachers use the administration interface of whole platform primary. It may be used internally for them, or they can present it to the students to gain a better understanding of the ongoing testing or real-time usage of educational platform. Teacher can also use and present a testing part of lesson (interface for students) and illustrate examples and procedures to be undertaken by students. There should be a couple of examples based on mentioned interface that is ready to offer the interactive form of test of knowledge gained from lectures and materials on those technologies.

The last optional part of each module consists of a *directory containing the default state* of the databases and other data used in testing. These allow semi-automated recovery of the starting conditions of the tasks for quick and efficient repeating of lessons.

The reason why the modules are divided in this way is that each lecture can be easily and effectively updated. Internet technology and its environment are rapidly changing and our platform should be able to react to that without a huge intervention of the programmer. Obsolete technologies are being replaced and current technology problems and their solutions need to be presented to the students.

C. *Technical sollution of the events capturing on the server side*

From the technical point of view, the very important functionality of the platform is to capture and analyze communication between server/platform and students [3]. The utilization, feedback and evaluation can be performed thanks to this. The platform itself is responsible for that feature.

Figure 5. Scheme of the server structure

The platform, via a special application written in .NET technologies, is able to monitor the requests that users send to the web server (in this case we use Apache as a web server). The basic scheme of platform structure during the testing is depicted in Figure 4. The application is also able to track information on the facilities which are currently communicating; it is able to detect the IP address, MAC address, browser type packet, the destination and source port of the packet [5]. It is also necessary to be able to put Apache modules to its original state and lead through the logs of all events. Finally, this application can read the data directly from the Apache

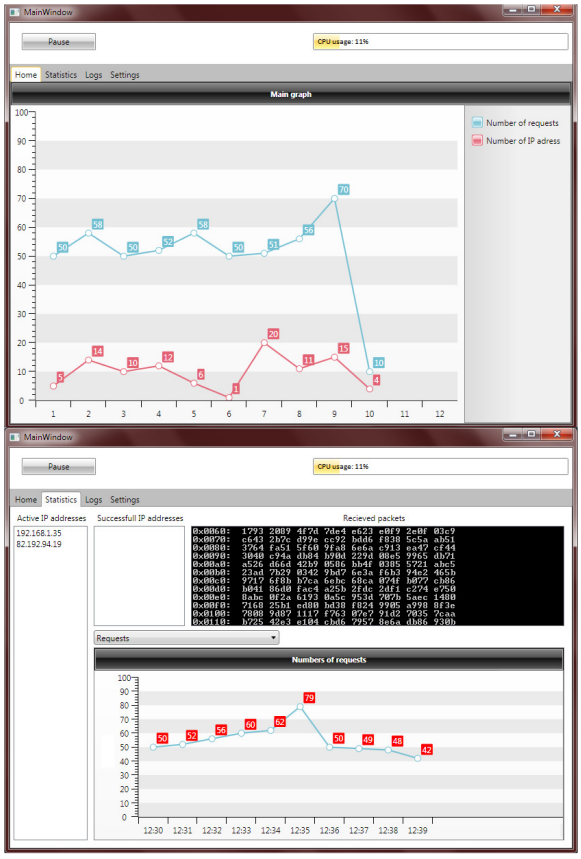

Figure 4. Administration application screenshots. The chart of server utilization and communication snipping is depicted.

application. All of these things what the application is able to do, can be displayed as charts, statistics or data tables. An example of server utilization chart is presented on Figure 5.

How it is mentioned above, the ability to capture communication and server state is crucial for our approach. This can be performed by a several ways on the server side:

- Incoming packet sniffing – it is based on some special components WinPcap and WinDump. These components offer functionality to read a data directly from the network adapter, parse it and filter this data based on some conditions.
- Information reading directly from the Apache application – it is based on Apache extended mode which generate special XML file with real-time operational information.
- Information reading from log files – Apache server, as well as another internet servers, creates log files included a huge amount of data about requests, responses, errors, etc. It is also an interesting source for users' behavior and communication analysis [6].

IV. CASE STUDY – PLATFORM USAGE FOR WEB APPLICATIONS SECURITY TOPIC

The current most common web security problems were included in the pilot version of the project. This selection of problems was motivated by the real situation of the Web applications area. The aim is to provide not only

information, but also practical examples to test problems discussed in terms of security of web applications and subsequent attacks on them. It is not necessary to introduce the topic the depth, but it is focused on the right directing the students within this subject. The following text describes a standard process of teaching based on our platform [2].

Teacher turns on the laptop (for presentation) and the device that acts a server role. Runs the platform on the server side and chooses lecture and materials. This starts the configuration process within the server environment. This process consists of system variables setting, ports configuration, starting of the listening of incoming requests and, optionally, deployment a database structure designed for testing. After this initial step, students can begin to connect to a running application interface – standard web page within web browser, see Figure 6.

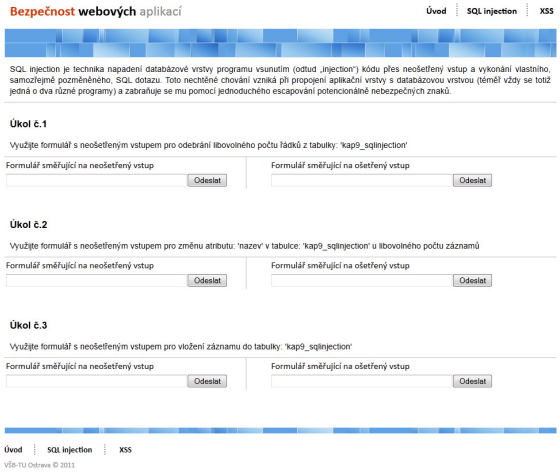

Figure 6. Screenshot of user interface (web pages) for students and their tasks (only in Czech version now).

Teacher can use the administration interface and start the presentation of a given topic.

The first topic is the SQL injection attack. After basic theory introduction the students can try to perform this attack within the closed and secured environment of educational platform. Students select the topic within theirs interface and get to the screen with the first set of tasks. The first exercise is a challenge to use untreated form input to write a query that will remove the record from the test table. During the students' testing the teacher is able to check the attempts of students in real-time thanks to administrative interface. Also the administrative interface offers information on Web server workload, current data in the database and its state and a list of queries that students are sending to the database server. At the moment when a successful attack is executed, the server can automatically interrupts the connection of all users and the information on attack can be presented. Now, the teacher can illustrate the successful attack and analyze it, as well as discuss the unsuccessful attack of other students.

Subsequently, the recovery of database to the initial state is performed. Other tasks to test knowledge of SQL injection can be based on adding and editing records in the database, deleting the entire database, create a copy of each, etc. The basis for these types of tasks is a form with untreated input. The knowledge and practice how to realize attack are perfect background to explain the approaches to secure the forms.

The second set of tasks is aimed at Cross site scripting (XSS attacks). The first task is to use an unprotected form input element to save attacker own malicious code that causes the firing of JavaScript method on the target page. This code is stored to the database and it can be generated as a part of regular web page content for another users. This can be dangerous with respect to power of JavaScript. To determine the successful attack the platform uses a regular expression applied to query that checks whether the input contains all necessary elements to induce the desired method. These elements are defined within the configuration of this task. As in the previous case, after successfully testing there is a time for illustration or discussion. Also, the database returns to its original state.

Of course this is just one of the scenarios constructed on our educational platform. The above examples show that the students will be able to test their knowledge and skills directly on the real server environment without any risky behavior within real operational environment. The result is that the students can learn how to secure the scripts and forms by interactive way.

V. Conclusion and Future Work

The educational platform for Internet technology is a new interactive way to bring the topics closer to the students and let them to test it based on examples that are ready for them [4]. The innovative approach of this solution is to deploy the application not on the level of the conventional practice, but especially in the context of interpretation lectures. This offers the teacher a simple tool, which contains everything needed to teach this dynamically developing area.

The current state of this project is in a pilot phase with massive development necessity. However, the general concept and prototype of the platform is already formed and it is ready for next extended implementation. The goal of our effort is to deploy this platform to the teaching of mostly all topics included within the Web applications development syllabus. This should be also the experimental operation of our platform in the real educational world. During this initial operation we would like to identify possible shortcomings and subsequently we want to share our platform both with professionals and students. Our aim is to provide innovative and effective tool for increasing the interactivity of the technologically based lessons. Also, the platform would be a basis for the students to start developing Web applications and to avoid common mistakes. It is good way how to put their practical skills to upper level already during the study process.

References

[1] D. Randy Harrison, *E-Learning in 21st Century: A Framework for Resarch and Practise*, Feb 2011.

[2] S. Shah, *Web 2.0 Security – Defending AJAX, RIA and SOA*, Dec 2007.

[3] L. Shklar and R. Rosen, *Web Application Architecture: Principle, Protocols and Practises*, May 2009.

[4] M. Bullen, *Making the Transition to E-learning: Strategies and Issues*, Aug 2006.

[5] http://www.wincap.org/windump/default.htm, Sep 2011

[6] http://en.wikipedia.ork/wiki/Tcpdump, Aug 2011

Emulating Cisco Network Laboratory Topologies in the Cloud

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***Abstract*—Presently a multitude of virtualization solutions have been implemented in both classroom environments and by students at home. Their success and widespread deployment made them an ideal surrogate to real hardware based laboratories and an excellent aid in the learning process. However, the intense hardware requirements often limit the number of emulated devices used, and the number of concurrent sessions. To address these issues, in this paper we propose a cloud-based virtual laboratory.**

I. INTRODUCTION

Among the most popular Cisco IOS emulation tools in recent years are Dynamips and Dynagen upon which the successful GNS3 environment is based. The usefulness of these tools in learning was an incentive for us, and prompted us to create a Virtual Laboratory (only VLAB further on) [1]. The VLAB provides a framework for virtualization of the network topology and enables registration, authentication, reservation and resource authorization for the student. The VLAB is implemented on a single Unix server and this represents a few issues which we would like to address. In this paper we take our existing VLAB environment a step further and move the existing implementation into the cloud to utilize the available computing resources.

Our motivation behind this effort is to be able to deliver new Cisco CCNP Troubleshooting laboratory lessons to students regardless of their location on a shared, cloud-based emulation environment. These lessons feature preconfigured networks which contain a bug, unwanted functionality or an undesirable byproduct which the student has to identify and reconfigure the network in order to achieve the desired result. Currently in class and on real equipment, the task of preparing the lab (cabling, base configuration, etc.) itself brings up new issues, which are not part of the lesson and therefore it makes the whole troubleshooting part more complicated and spread out in many different directions. This way it is quite difficult to focus on the topic the lab was meant for, because the student does not see the expected outcome described in the lab until he solves the issues he added with the installation of the lab itself. Having dedicated hardware and preinstalled configurations for the Cisco CCNP Troubleshooting course is, in our view, inefficient, time-consuming and expensive. Therefore we propose to conduct laboratory lessons in this course in a virtualized environment capable of running many concurrent sessions with automatic configuration deployment to the emulated network devices. A natural candidate for addressing this issue was our existing VLAB.

Utilizing VLAB during lessons helped eliminate problems with cabling and the need to prepare configurations before the actual lesson begins. It can be used by up to four students at once with present hardware configuration (4GB RAM). High availability of virtual laboratory allows students to use it up to 96 simulation hours a day and 672 simulation hours a week. If single student needs to use it 3 hours a day, VLAB can be used by 224 students [2]. However, VLAB being limited to a single server, resources were still scarce and usage had to be scheduled in advance. The VLAB server also represents a single point of failure because an unexpected outage renders all pending emulations useless and configurations are lost. We will cover the original architecture of the VLAB in the following chapter and address its issues in the chapter III.

II. ORIGINAL CONCEPT

Originally, the VLAB was conceived as a server-centric model where at the heart of the system was a single Unix-based server optimized for virtualization and emulation tasks. As per the requirements, the server had to support multiple concurrent dynamips hypervisor processes. User-mode Linux was deployed to provide PC emulation and together with the VLAB web-application, these three components formed the student interface. Students would log into the VLAB web-application and schedule a laboratory lesson, which would become available to them via a combination of the Server IP address and TCP port mapped to the instance of an emulated device running on the Server. The whole concept is depicted in Fig.1 below.

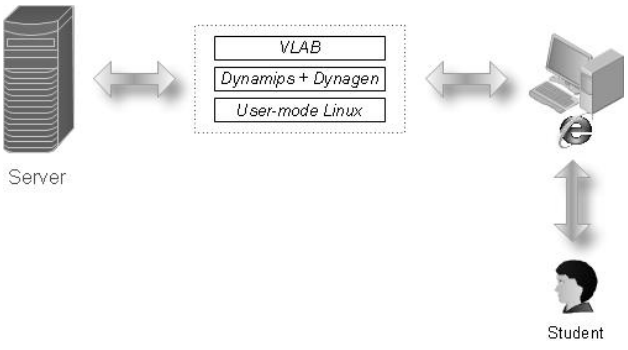

Figure 1. A high-level overview of the VLAB

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After a laboratory lesson is selected and scheduled, the topology together with an initial configuration is displayed to the student (see Fig.2 below).

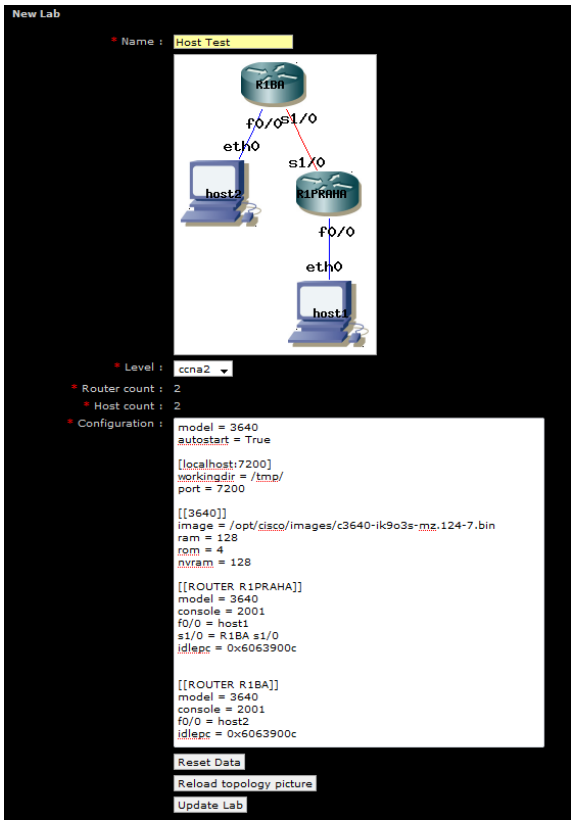

Figure 2. A loaded laboratory lesson in the VLAB web-application

The task of configuring the emulated devices itself can then be done my means of an applet which has established connections to all of the emulated devices (see Fig. 3) or by directly establishing secure terminal session (SSH) to the VLAB Server.

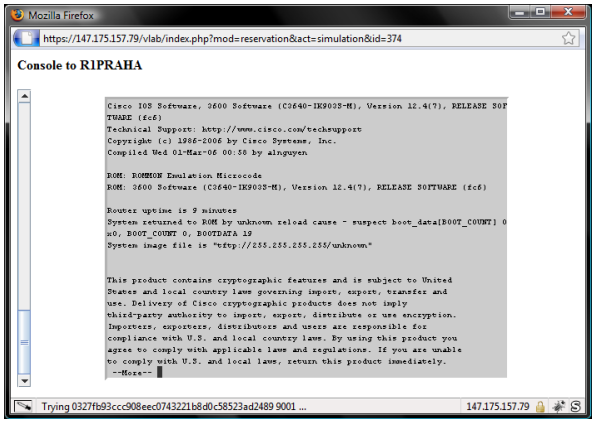

Figure 3. The configuration applet in the VLAB web-application

A major advantage of the VLAB, above those already listed, is the ability to automatically score a completed laboratory lesson after the student has finished. This scoring is done in a twofold manner. First the configurations are compared to correct reference configurations and secondly, the entire topology is functionally tested to determine whether connectivity was established as desired.

III. Proposed Concept

To address the shortcomings of the VLAB – mainly susceptibility to being overloaded with increasing number of students, the upper limit on the number of emulated devices and the fact that it represents a single point of failure, we propose a cloud-based virtual network laboratory.

A cloud computing environment might provide an ideal solution to the issues we face when delivering the Cisco CCNP Troubleshooting course. Dynamically allocated resources will serve well in the academic environment as, in our view, there are a lot computing resources available at universities, yet not many of those are utilized to their maximum potential at all times. For our purposes we have chosen the Ubuntu Enterprise Cloud (only UEC further on), because it provides an easy to use open-source virtualization capability, applications and flexibility to help deploy a cloud within an organization [3]. It is important to note that UEC is compatible with Amazon EC2 cloud. The UEC is composed of the following key components:

- **eucalyptus-cloud** – cloud controller, front-end services
- **eucalyptus-cc** - includes the Cluster Controller that provides support for the virtual network overlay
- **eucalyptus-sc** - includes the Storage Controller
- **eucalyptus-walrus** - includes the Walrus storage system
- **eucalyptus-nc** - includes the Node Controller that interacts with KVM through Libvirt to manage individual VMs

We have modified the original VLAB architecture (see Fig. 1) and broke it up into two layers: bottom and top (see Fig. 2). The bottom layer contains network nodes which are part of the cloud. There should be a minimum of 2 network nodes in the cloud active at any given time. One of these nodes will be dedicated as a Cloud Controller which will manage all the other nodes, virtual machine instances and available images and resources inside of the cloud. Other nodes in the cloud will function as resources of computing power and storage space, hosting the virtual machine. These nodes are running Ubuntu Linux Server, which provides a scalable and manageable cloud computing solution. The number of nodes in the cloud is not limited which is important for future growth.

The top layer in our architecture is composed of the actual virtual machine. Users use cloud resources by an interface composed of our existing VLAB, a combination of Dyn@ng and Mindterm which is a Java SSH client applet [4, 5]. It is important to note at this point, that all of the components we have chosen are free and in the public domain. We have integrated these components with little effort and only minor changes were made to the existing VLAB environment. The Fig.4 below represents a high level overview of our proposed architecture.

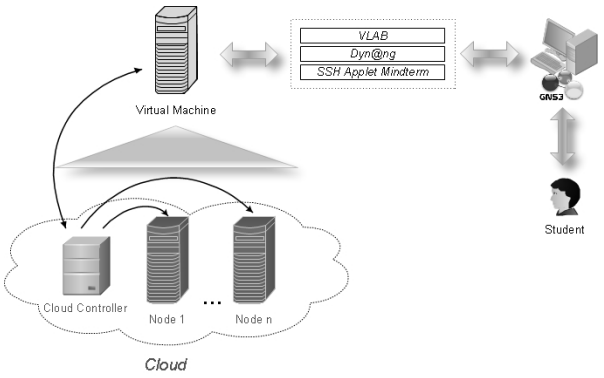

Figure 4. A high-level overview of the proposed architecture

It is important to merge all the components of the user interface into an easy to use, reliable and secure component of our architecture.

Dyn@NG was chosen instead of Dynagen because of the immense advantage it offers by offloading running emulations. This in turn enables us to run a large number of concurrent emulations. Another advantage is the fact that students now don't have to have user accounts on the virtual machine (Server) to gain access to their running virtual laboratory. During implementation we have identified a security imperfection of this approach. With Dyn@NG, the resources are becoming available to everyone, because to enable load imposed by the emulation from client to the server to be moved, we need to make the ports on which the hypervisor and device consoles are running available. This situation can be partly resolved by dynamic firewall measures limiting the availability of those ports to only a selected IP address.

Mindterm was chosen to tunnel ports from particular cloud node which is running the emulation to the student's workstation. From the student's point of view, the whole process of connection establishment is transparent. Mindterm, now integrated into our VLAB web-application will, after laboratory lesson start and resource allocation, establish a secure (SSH) session with the virtual machine and configure SSH tunnels as mentioned above. To integrate the Mindterm applet into our VLAN web-application, the following code is crucial and present in every student's running laboratory lesson:

```
  <APPLET
CODE="com.mindbright.application.MindTerm.class"
  CODEBASE="./" WIDTH=0 HEIGHT=0>
      <PARAM NAME="archive"
VALUE="mindterm.jar"
      <PARAM NAME="sepframe" VALUE="true">
      <PARAM NAME="debug" VALUE="false">
      <PARAM NAME="protocol" VALUE="ssh2">
      <PARAM NAME="server"
VALUE="vlab.fiit.stuba.sk">
      <PARAM NAME="port" VALUE="22">
      <PARAM NAME="username"
VALUE="logged_in_username">
      <PARAM NAME="password"
VALUE="logged_in_password">
      <PARAM NAME="quiet" VALUE="true">
      <PARAM NAME="alive" VALUE="20">
      <PARAM NAME="term-type"
VALUE="xterm-color">
      <PARAM NAME="geometry"  VALUE="80x24">
      <PARAM NAME="local0"
VALUE="/general/127.0.0.1:7202:localhost:7202">
      <PARAM NAME="local1"
VALUE="/general/127.0.0.1:1051:localhost:1051">
      <PARAM NAME="local1"
VALUE="/general/127.0.0.1:2006:localhost:2006">
  </APPLET>
```

The above underlined sections of code are dynamically generated.

The hereby proposed and described cloud-based virtual laboratory was successfully implemented and the preliminary results from our testing are listed in the following chapter.

IV. Preliminary Results

We have conducted preliminary testing on our proposed architecture, focusing on the ability of Dyn@NG to spread requested emulations on available resources in the cloud. On the below figure (Fig. 5), the load imposed on the virtual machine is plotted over the course of the day. The load decreases as more resources are allocated inside of the cloud.

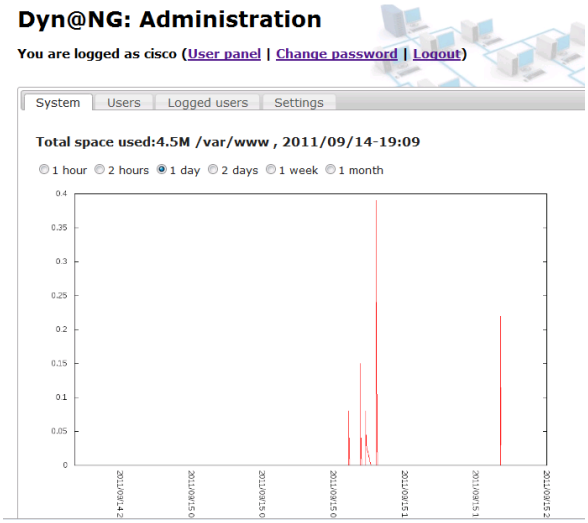

Figure 5. Plotted one-day load imposed on the virtual machine

On the below figure (Fig. 6), please observe the port forwarding, as established during a student session. Note, that the student does not have to have an active account on the virtual machine.

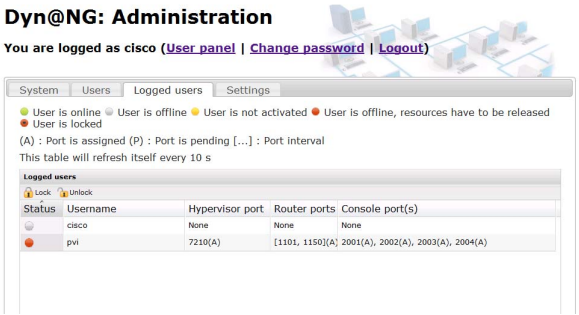

Figure 6. Port forwarding as seen in the administration of Dyn@NG

Since the running laboratory lessons are being emulated on resources inside of the cloud, the student doesn't have access to packet dumps. Therefore we utilize the Dyn@NG capture functionality to provide the packet capture function to the student via the VLAB web-application (as seen on Fig. 7 below).

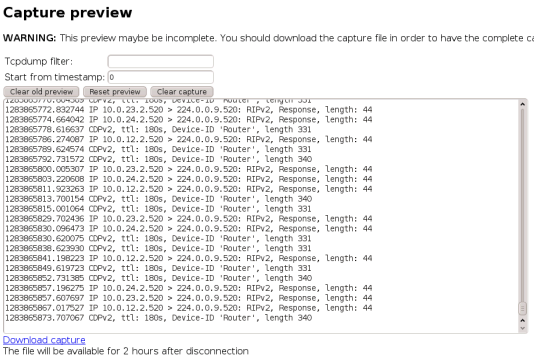

Figure 7. Dyn@NG packet capture feature

We have experimented with creating multiple simultaneous student sessions in our implemented cloud-based virtual laboratory. We have also integrated the Dyn@NG packet capture feature with our existing VLAB web-application to allow the students to implement packet sniffing on their running emulated topologies. This might greatly improve the learning experience, because in a real wired network laboratory it is not possible to capture packets on serial interfaces. Therefore, solutions to some networking issues might become more apparent to the student than without the ability to observe network traffic directly. At present time we have not concluded our testing of the proposed cloud-based virtual laboratory. Current testing however shows signs of great improvement over our previously implemented VLAB environment.

V. COMPARISON

In this chapter we compare our newly proposed solution with the original VLAB. The cloud-based solution is, in our view, a modern approach to solving issues where large amounts of computer resources need to be accessed quickly, securely and reliably. We believe that our proposed architecture which integrates the UEC, Mindterm, Dyn@NG and our existing VLAB is a good approach when it comes to emulating the network topologies we are faced with in the Cisco CCNP Troubleshooting course. We have not yet finished our testing of our proposed concept, yet we believe that the great improvement will, at least performance-wise, help us in delivering high-quality virtualized courses.

CONCLUSION

We have proposed a cloud-based virtual laboratory, building on our previous single-server virtual laboratory, in order to deliver the new Cisco CCNP Troubleshooting course. To accomplish this task we utilized existing approaches to cloud-based computing (UEC) and available secure terminals (Mindterm) to make the best use of load-balancing Cisco IOS emulation (Dyn@NG). The biggest advantages of our proposed solution are high availability of computing resources, scalability to allow satisfaction of possible future high demands and most importantly, a better learning experience for the students.

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REFERENCES

[1] I. Grellneth, M. Bielik, S. Gula, P. Marko, V. Michalec, P. Peti, and Z. Schusterova, "VLAB at the Institute of Computer Systems and Networks FIIT STU" *Acta Electrotechnica et Informatica*, vol. 10, pp. 65-71, April-June 2010

[2] I. Grellneth, Z. Schusterova, "An Aproach to Implementation of Virtual Network Laboratory" *In Proceedings of the 10th International Conference Virtual University VU'09*, December 10-11, 2009, Bratislava, Slovakia. ISBN - 978-80-89316-12

[3] UEC/Architecture [online], cited on September 14, 2011 https://help.ubuntu.com/community/UEC/Architecture

[4] Dyn@NG [online], cited on September 14, 2011 http://netgroup.polito.it/tools/dyn-ng

[5] Mindterm – World-class Java SSH2 Client [online], cited on September 14, 2011 http://www.cryptzone.com/products/agmindterm/

Teaching one Language in More Depth is better than Many Languages Superficially

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***Abstract*—This paper describes the findings on students' problems in programming learning that have been captured through interviews and essays. It briefly introduces the new class which we intend to use in programming teaching.**

I. INTRODUCTION

We currently deal with the issue of rebuilding a series of programming courses at the Faculty of Education at Trnava University in Trnava. The programming belongs to the less easy manageable for the students; therefore teachers worldwide and in Slovakia constantly look for innovative ways of programming teaching. We have opened that question, too.

The question is: how to manage programming courses, so that students would have better results absolving them? The greatest chasm within the teachers worldwide is in the selection of first language (and programming environment). Next point is that the programming courses are put into specific time-frame, but master single programming language can take years of study.

We should regard the fact, that significant per cent of students coming up to our faculty to study Computer Science Teaching have never met any programming language before. Worse, many of them have no idea that they will have to learn to program after they join the faculty. If we put too much information to such as student, he will lost the overview quickly, fails in study, and will leave, eventually.

Despite of the chasm in the selection of first language, we decided to use Java as the first language and BlueJ as the programming tool (environment). An interview series with the students showed to us that less acceptable for them is to learn many programming languages and work with many programming tools (or environments) than learn single language and single tool. We decided to unify programming language and tool taught. Java and BlueJ is our choice.

II. JAVA IN PROGRAMMING TEACHING

There are several kinds of beginner programmers – students. Students studying at our faculty are future computer science teachers. They are different than "standard" computer science students. We have to adapt our requirements to their needs. As we mentioned, discussions about proper first language and first programming tool are in progress, for years. The view is changing with the current trends in programming and with new programming languages and environments. Computer science praxis influences the computer science teaching, and so it should be…

As we found out by studying several public information sources ([7], [1], [5]) and performing interviews with several teachers working at universities in Slovakia, nowadays, three groups sustaining different programming languages in computer science teaching are formed. The supporters of each group have their own opinions, and it is very hard to resolve the dispute. They are as follows: 1. to teach using Pascal or Pascal-like programming language (Pascal, Object Pascal, Delphi…); 2. to teach using C-like programming language (C++, C#, Java…); 3. to teach using different language – this group is autonomous and prefers completely different languages as Python [9], Lisp, Scheme etc.

Pascal is, for example, a language designed for teaching. It is a language of verbal keywords and operators (e.g. begin, end, procedure, and, or, mod…). However, all these keywords are in English. Experiences taken over years showed us, that English is, despite the wide-spread in computer praxis and computer science, not routine for the Slovak students. That means that human readable keywords of operators and programming structures don't play such important role for Slovak students as some other factors. Languages using C-like syntax are more symbolic (&&, ||, ++, +=, etc.). These symbols have for most Slovak students the same meaning as English human readable keywords. Students just have to memorize them… Currently, we have no solution for this issue. We can just say that this is not the key factor for the choice of language taught. Personally, I can say that foreign language makes no problem for a man, who wants to learn to program. I, for example, started to learn programming in Basic (programming language using pure English keywords) with help of German written manuals as eight, maybe nine-year old boy, with having had no idea about syntax, algorithms, and with zero knowledge of English or German. But… often we are forced to teach people, who don't want to learn to program. (That's the point…)

Let us take a small thought about transition between programming languages during study. Surely, the transition process is serious problem just like the syntax of programming language is. Our past students had no other choice, just accept the fact they must change the programming language almost each two terms. We have noticed that this is a problem for them, and we convinced of this through interview series with the students. Several students said: *"We have had to teach several times the programming from the ground… You suppose that we are able to program in all these languages, but the fact is that we are hardly able to write any basic algorithm in some of these languages…"* We could not ignore these

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expressions. So we decided to teach one language in more depth than several languages superficially. One question stayed open for some time period: which language? We knew that transition from C-like language to Pascal-like language is easier than the reverse. That has indicated to teach some C-like language to make the students prepared to the reverse (easier) transition way in the future, after leaving our faculty… And after several another recommendations the faculty took the decision to teach Java. We can say that the final choice of the starting programming language taught at our faculty has been taken with regard of other benefits of the language chosen.

Joel Spolsky published an article full of criticism against Java. He says, what happened to the programmers' hard work? [6] He says: *"Java is not hard enough to be used to discriminate between great programmers and mediocre programmers."* And more: *"…the ability to understand pointers and recursion is directly correlated with the ability to be a great programmer."* Sure, this is a good point for computer science students, but is for future teachers too? Spolsky is talking about permanent decrease of requirements made for the students. Yes, there are no doubts that with teaching someone who, as we expect, will develop commercial software, we take the responsibility to teach him how to make good programs, good algorithms, and how to be a good programmer. But with future teachers we are in different position. Our students have problems with more basic language features, they don't miss pointers, and I think they would be thankful to Java for covering pointers deep under layer visible to programmers, if they knew what the pointer is. I think Joel Spolsky is right, but with "classical" computer science students. Maybe there should not be a differentiation between "classical" computer science students and future teachers, but it is, nowadays. And I think it will be for a long time in the Slovakia (and some near countries, too; if anybody wants to know more about our school system, please, write to me…). We should, first of all, produce teachers that are able to program, and, at least, able to create basic algorithms.

I am not strong Java supporter. I did not know Java before 2009. Until then I was able to compare only Pascal and C/C++. After meeting Java, I was able to compare it with other two, and also able to better understand some claims that Java is more close to (Object) Pascal than C/C++. Java has C-like syntax, but I see something different in it. I think it is better designed. The whole language philosophy is different than the C/C++. It is strictly object oriented, and has strong object basis with optimized algorithms, which can be used by beginner and professional programmers equally. Java claims to be simple, object oriented, familiar and more [8]. We decided to teach Java, but more important is that we decided to teach single language in introductory and following courses. So the students have better chance (more time) to learn about how to make programs before they meet some other language (and before they are forced to invest the energy into the transition). Maybe/I think the decision with Java was not as bad. For the students will be less painful to go off from Java to simpler language than the reverse. But we have now the responsibility to make introductory programming courses motivating enough.

III. Anonymous Essays and Interviews with our Students

If we want to find answers for some kinds of questions, we have to ask. In the anonymous essays students should to write their opinion on programming teaching at our faculty, the strengths and weaknesses they are able to see. Also, the teacher has made many interviews with the students, whose learn programming at our faculty now, or learned it in the past. He tried to find out, what are the most problems in the programming learning. It has been made in academic year 2009/2010.

Mostly, the students wrote about "big problems in understanding" the teacher's explanation. They noticed that "only few schoolmates really understand the matter." Apparently, they often talked each other about the problems with programming learning. The biggest problem was to "catch the train." I think that this can always be a problem for few students, but not for the most of the classroom. After this happens to a student, it is almost impossible to get in and learn continuously. Different students wrote about different parts of the curriculum which they don't understand, finally each part of the curriculum has been mentioned at least once. After more detailed analysis of the essays we tried to get the most problematic parts. Ironically, they were exactly the elements we worked most often with. The tireless repeating of the language basics (branching statements, loops, creating the conditions, the methods definition…) seemed to have no effect on our students' understanding. Only simplest language elements (as "if" and "if-else" statements) were mentioned as really easy understandable.

Doubtless, the students need time to understand even basic language concepts. Indeed, the subject number two in the essays was "the time." Students often asked to "slow down the tempo." They often complained about the fast progress. They proclaimed that they need time for thinking about discussed problems. Although they did not forget on some situations, when teacher asked all students to think about some problem, but it was not often enough for them. Accepting such kinds of requests the tempo has slowed down, but students again proclaimed that the tempo is still too fast. On the one side, we understand this. There is an effect called Cognitive Overload ([4]; it is related to Cognitive Load Theory, which Mark Guzdial mentioned in an article about introductory programming courses [3]). We should avoid letting our learners suffer from it. Have enough time for thinking is important, we agree, but on the other side there is no straight solution. Programming courses have specific time-frame. We are unable to teach all the necessary subject matter with slower tempo and it is not possible to get more time for programming courses. We could give more stress on homework, and we could (again) try another way of teaching. For example, try to apply some good elements of the Flow Theory [2] by Mihály Csíkszentmihályi. It is always good to have clear goals and immediate feedback… We would like to experience if and how would be this applicable in our teaching, but the final success is mainly on the students themselves and their inner attitude.

Another often mentioned problem was "the students' inequality." Most of the students asked to slow down, but several of them asked the right opposite. They claimed

"we are moving like a snails," and complained about slow schoolmates doing too much typos. They showed not much understanding to the slower classroom mates. This is unavoidable – experienced students will be bored and beginners will claim that the tempo is too fast… Some students were able to fully reflect that they need more autonomous action – at home alone or with the help of the friends or family members (e.g. more experienced brother). Another few complained about hidden "illegal activities" during classroom training, like Facebook browsing and other amusements… This is inacceptable. We will draw the consequences in the future.

Individual problem is the memorising whole programs or their parts without understanding them. Some students admitted this, and we have observed such manners too. That problem is connected with the distorted concepts of computer science. Many students were surprised by the fact that they should to learn to program. They often have no idea what it exactly means "to program." Maybe at least this fact will change in the near future…

The last information taken from the essays was the "lack of Slovak study materials." Changing this needs just time and hard work to make such materials. We constantly work on new materials, because this is one of the most objective students' requests.

The interviews confirmed some information gained from the essays. Again, the key points were:

- the lack of time – students considered the two terms introductory programming courses as insufficient;
- the chasm between what the teacher wants to explain and what really students understand – experienced students said that the explanation was simple enough, and beginners said that it was too professional, technical;
- the inner motivation – many students do not step into this study programme with the correct concepts, their concepts were often distorted; after realizing that they will have to learn to program they become being demotivated;
- the team – it is important to support the team building – experienced students should help to the less experienced, students should cooperate – helping each other to learn.

These and some other information were gained from the students. Some experienced students told us, they learned by modifying existing programs. They suggested that incomplete examples or programs ready to modification could be given to the beginners as an exercise. This is not a bad idea. We have heard about such techniques [3], but never tried it until now.

IV. The New Plan – Use New Graphics Robot

All the circumstances consecutively led to creation a new tool – Graphics Robot. The Robot is a Java class and it is a successor of the "Korytnačka" class (which means "turtle" in Slovak language; development of Korytnačka started approximately in august 2010). Robot class does not have anything to do with original java.awt.Robot class. It is independent class made for graphics oriented programming partially similar to Logo. The name has been changed from Korytnačka after dishonour original organic name by students, and after advancing the class functionality far behind the borders of original (simpler logo-like) philosophy. The new name sounds international, but this is a coincidence. In fact, the whole class is written (like its predecessor) with regard to Slovak students. All methods and properties are named in Slovak, and whole documentation is written in Slovak.

The simplest Robot's feature is that it can paint a line during movement, just like Logo turtle, but it has many other features against the original turtle. The Robot is able to work in both Cartesian and Polar coordinate systems. It accepts absolute and relative coordinates, paints images, plays sounds, contains tools for basic events handling (mouse, keyboard, timer…), can do some primitive automated actions (like uniform straightforward movement, accelerated movement, and uniform or accelerated rotation), can generate some basic Java shapes (dots, circles, polygons, rotated ellipses, squares, and rectangles…), draw the outlines of generated shapes or fill them, paint texts, work with text files, and much more. Many methods are polymorphic, some are getters, other are setters, and some Robot methods are intended to be overloaded – they are invoked automatically in specific situations and the Robot changes its behaviour after overloading them. We can use all that to better explain the object oriented features, like the method overloading, polymorphism, and their purpose. The new Robot is intended to be used in object oriented programming teaching.

Eventually, here is an example showing how to program a robot to follow last mouse click:

```
rýchlosť(10, false);

new ObsluhaUdalostí()
{
    @Override public void klik()
    {
        cieľNaMyš();
    }
};
```

Ironically now we have to translate some Slovak words back to English to make the example understandable, because the Robot (as we mentioned) is written using Slovak language. The same example in English would look like this:

```
velocity(10, false);

new EventHandler()
{
    @Override public void click()
    {
        targetToMouse();
    }
};
```

The example must be enclosed in class definition that extends (inherits from) the Robot class. The fastest way is to put it in the constructor.

I. Conclusion

The programming teaching is wide area. There are many ways how to organise introductory courses. We described our situation, the decision made at our faculty, and the new tool (Java class package) developed to cover that decision consequences. Programming probably never comes to be smooth for all different kinds of students, but we can always try to make this process as motivating as possible. The students which are interested in programming will appreciate it, and for the other students (not enough motivated) may be this at least a welcome step.

Acknowledgment

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References

[1] Antonič, M.: *Delphi namiesto Javy.* [online]. http://miso.blog.matfyz.sk/p12296-delphi-namiesto-javy. Accessed: 29. Feb 2010.

[2] Csikszentmihalyi, M.: *Beyond Boredom and Anxiety: Experiencing Flow in Work and Play.* San Francisco : Jossey-Bass, 1975. ISBN 0-87589-261-2.

[3] Guzdial, M.: How we teach Introductory Computer Science is wrong. In *Blog at Communications of the ACM. Trusted insights for Computing's Leading Professionals.* 2009. [online]. http://cacm.acm.org/blogs/blog-cacm/45725. Accessed: 28. Feb 2010.

[4] Herrod, J.: *Cognitive Overload.* 2000. [online]. http://www.jchconsulting.com/fall2000/. Accessed: 1. Aug 2011.

[5] Kotrbčík, M.: *Hocičo namiesto Delhpi a Javy.* [online]. http://mito.blog.matfyz.sk/p12304-hocico-namiesto-delhpi-a-javy. Accessed: 29. Feb 2010.

[6] Spolsky, J.: *The Perils of JavaSchools.* 2005. [online]. http://joelonsoftware.com/articles/ThePerilsofJavaSchools.html. Accessed: 28. Feb 2010.

[7] Ščerbák, G.: *Java namiesto Delphi.* [online]. http://gscerbak2.blog.matfyz.sk/p12293-java-namiesto-delphi. Accessed: 29. Feb 2010.

[8] *The Java Language Environment.* [online]. http://java.sun.com/docs/white/langenv/Intro.doc2.html. Accessed: 6. Apr 2010.

[9] Zelle, J. M.: *Python as a First Language.* [online]. http://mcsp.wartburg.edu/zelle/python/python-first.html. Accessed: 28. Feb 2010.

Supporting the development of digital competences of pupils and teachers

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***Abstract*—The author of this article dealing with issues of developing digital skills of students in primary and secondary schools. In addition to devote his attention now processing the results of testing students in various grades of the Slovak Republic and Czech Republic. Testing was conducted at several pre-selected objects and to analyze the results allow a comprehensive analysis of the cognitive level of students participating countries. In the project participated in three different institutions: University of Trnava in Trnava, the University of Ostrava and Methodology and Evaluation Center, ops in Ostrava. The obtained results of the project, as well as the objectives, specific focus are outlined below.**

I. INTRODUCTION

Internet has long been not only a medium allowing the sharing of information in text or graphic form or medium providing "chat" and e-mail based on a text. Today, in connection with the Internet constantly increasing development of technical means, such as parameters and data networks offers a wider range of options developed interactive communication [1].

Information and communication technologies (ICTs) bring with them a wide range of possibilities for their application in the teaching process. In terms of stages of the learning process are the application of IT from the motivational phase, exposure and fixing phase after finishing the diagnostic phase. The international project ERDF titled "Diagnostics of knowledge and skills of pupils in CR – Slovakia border region, focusing on their development," we implemented the use of IT in order to develop students' digital skills on the one hand, as well as development of teachers on the other. In addition, it is one of the diagnostic phases of at least used to the application of IT compared to other phases of the learning process.

In addition to the results of international comparative studies, PISA and PIRLS shows that the quality of education in Slovakia has a long-term downward trend. It shows that the content, but mostly learning how not to meet the requirements of the current labour market [2]. As the Sotáková: "There may be more, we will mention only the most important: passive reception of information at the expense of their usefulness in life, individualism at the expense of teamwork, with easy access to information, lack of internalisation and the like. In Slovakia there is a long-term development concept of the education system" [3].

In Slovakia there is a long-term development concept of an educational system aimed at stopping the above-mentioned adverse trends and innovation and modernization of curricula and teaching methods and the increasing competence of teachers in the education process [4]. Among other things, to improve the quality of the curriculum can be a vital and participate in national or international projects (ESF, ERDF…). These can often be a pragmatic contribution to the intended target groups to develop specific competencies. One of the following oriented projects is a project that was implemented over three years to develop digital competence through opportunities to test their students and then determine their cognitive level. In the next section characterize a particular course of project implementation.

II. PROJECT DESCRIPTION, OBJECTIVES AND SUPPORT INFORMATION LITERACY

Improving the quality of education in that country is also reflected in the growth of national economy. If the leaders of the country preferred need to build quality education system (i.e., building cutting-edge content of study programs, quality teacher training, availability of sufficient and high quality material and technical equipment of schools, as well as lifelong upgrading of skills and supporting the acquisition of key competences as the body and learning object) then the support of educational and regional projects is one of the possible solutions to contribute to this goal. One project, which was, inter alia, its content also aims to increase digital skills of the ERDF project was titled: "Diagnostics of knowledge and skills of pupils in CR – Slovakia border region focusing on their development."

The project was approved in 2008. Implementation of the project was in a period from September 2008 – August 2011. Project leaders were: Ostrava University in Ostrava (principal investigator), Trnava University in Trnava (the main cross-border partner) and Methodology and Evaluation Center in Ostrava. The project was funded 85% from the European Union ERDF (European Regional Development Fund). Fund designated for economic and social development of the European Union (its member states) aimed at reducing disparities between disadvantaged regions to supporting economic growth, increasing competitiveness in the employment…

Project involved more than 200 primary and secondary schools (including grammar), of which 155 schools from the Czech Republic and 45 schools in the Slovak Republic. A total of 6,231 students tested. Testing could only attend school (primary and secondary) in the border region SR (School of Trenčín, Trnava and Žilina) and the

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CR border (Moravian, Zlín, South Moravia). Other schools from other regions were not included in the project. The project was divided into two stages of testing: testing input (year 2010) and testing output (year 2011). Obtained and statistically processed the results presented below.

The aims of the project were:

- intervene in the situation in education on both sides of the border,
- identify the causes of the educational deficiencies of elementary and secondary schools,
- develop core competencies students,
- enhance the quality of schools,
- enhance the educational potential teachers,
- strengthen the competitiveness of the region through human resource development and education,
- enhance cooperation between all stakeholders in the educational process.

The specific objectives of the project were:

- verification of knowledge of pupils 3, 5 and 7 school year and 1 and 3 year of high school courses: mathematics, mother tongue (or Slovak. Czech language), foreign language (English or. German), science foundation (biology, chemistry, physics),
- identification of problem points in education,
- specification and design changes in the approach to teaching,
- implementation of teacher training (eLearning) – 800 teachers,
- organize three international conferences for teachers – introductory and two comparative,
- strengthen contacts between the actors and the mutual sharing of experiences,
- comparison of test results between schools,
- implementation of teaching approaches in the educational process of evaluating the relative increase in knowledge,
- improve the quality of education,
- promote and develop human resources in accordance with the requirements of the knowledge economy.

III. Project Realization:

Overall, the project has been categorized into several separate phases of implementation. In the first phase of the project were prepared tests and testing technical support (server, database, web interface testing). Have been designated (selected) vocational didactics, methodology, who had the task on the basis of educational standards and performance standards to propose specific tasks that could be used in individual tests for individual subjects (i.e., the Slovak language, mathematics, foreign language – English or German language, physics, biology and chemistry).

Prepared on the basis of the following tasks have been developed pilot tests, these were then tested on a sample of students and checked again the methodology to prevent the use of suspected problems (suspected activity – more than 80% success rate, less than 20% of the success of the models) in the tests. It was also checked by formal, but also stylistic page of all the tests. Followed by another phase, this was the initial testing (first test). The first phase of testing was conducted in 2010, the time of testing was determined for four months (February–May). After implementation of the testing was obtained from the testing results are processed and subsequently evaluated. Based on these data, the results obtained were analysed for levels of competence (skills), and then made specific recommendations in the form of methodological shortcomings such as exercise, if possible as much as possible to reduce or eliminate. Methodological guide for teachers on the recommended methodology used in universities throughout the school year.

In the next stage, after 12 months was again made the second round of testing – test output. This was realized on the same sample of schools, but was offered the opportunity of involvement and new schools. The difference between schools that were included in the first round of testing and those that were included in the second round of testing was that the schools integrated in the second round of testing has not been evaluated relative increase in students.

As mentioned above, after passing exit test, the relative increase was observed that students achieve course with the assumption that their cognitive level of the course will be higher. These results were processed in the form of "Test reports." These systems were automatically generated and divided into three groups:

Report to the Director – contains a summary of all tested students, and recommendations that the director should be taken into account in the further education of their students. Of course, the report also contained data on which the school knew what the level of the object of which compared to other schools.

Report to class teacher – % contained recommendations on how many students in which subject and which specific responsibility or not the problem.

Report to the pupil – containing specific recommendations on the level of individual competence.

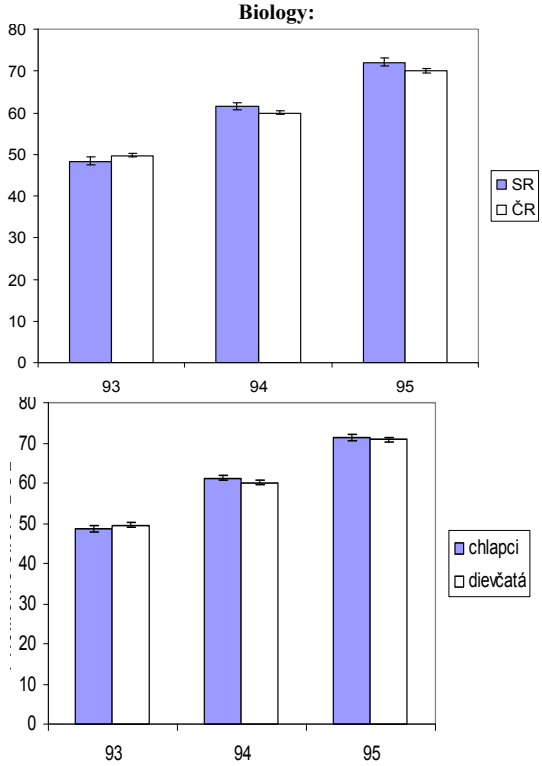
IV. Analysis of the Results Obtained in Testing

As already mentioned above, the second round of testing was conducted in early 2010. After passing the test was carried out comprehensive analysis and evaluation of admission testing of pupils and students of schools involved in the project. Test results were analysed by multivariate statistical test (ANCOVA, MANCOVA) correlations (Pearson). According to the analysis that the project carried out by Paul Prokop. Differences in test results between the SR and CR, as well as differences between the sexes overall results were not significant [3]. In some subjects, however, significant differences were noted. E.g. differences in the results of physics at secondary schools were quite clear – the boys consistently achieve higher average scores than girls.

Activity of innovative teaching aids directly followed up by testing the input of knowledge and skills students 3, 5 and 7 grade of primary school and first grade grammar schools and secondary schools. In these teaching materials of the tested objects are now ready to print, are offered some feedback and advice to teachers to help improve the skills of students. It places them in a particular emphasis

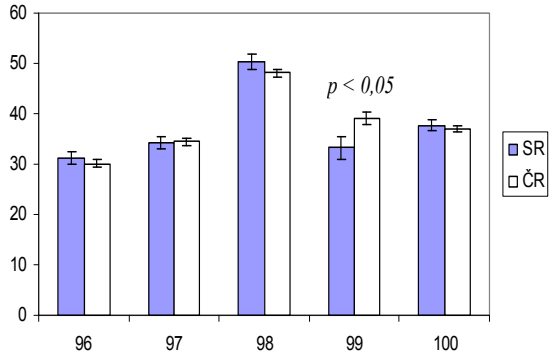
on those aspects of education, such as problem solving, group work, problem solving and project below. Awarded the role to contribute to the development of creativity of pupils, the thinking, the courage to grasp the problem and find a way to self, to experience the exciting action if the joy of finding their own solutions to problems. The authors of these teaching materials are trying to equip pupils and students the necessary knowledge and skills they will need for their future application in personal, professional and civic life. Below is a graphical representation of test results from the seventh grade:

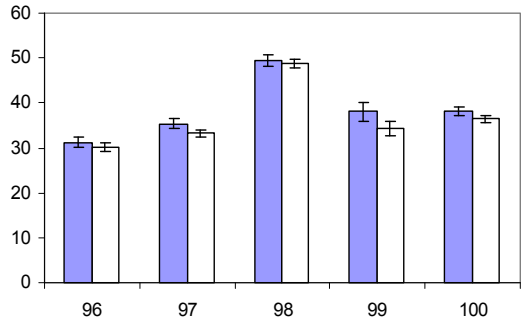
Biology:



Skill 93 – Perceptions of the broader context
Skill 94 – Graphic art
Skill 95 – Orientation and work with technical terms
Level of education: 7

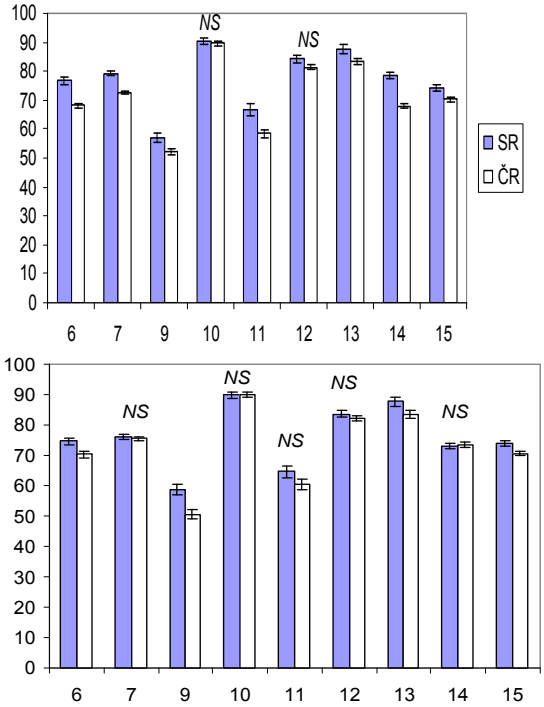
Physics





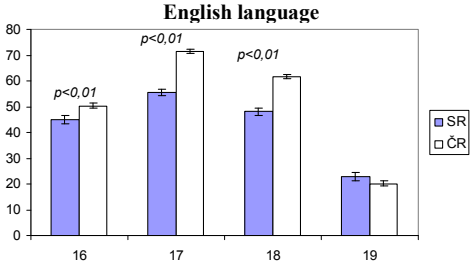
Skill 96 – Identify and correct use of terms
Skill 97 – Qualitative and quantitative description…
Skill 98 – Explaining and predicting phenomena
Skill 99 – Graphical perception, creation…
Skill 100 – Application of knowledge, use…
Skill 101 – Observation, experimental measurement
Level of education: 7

Mathematics

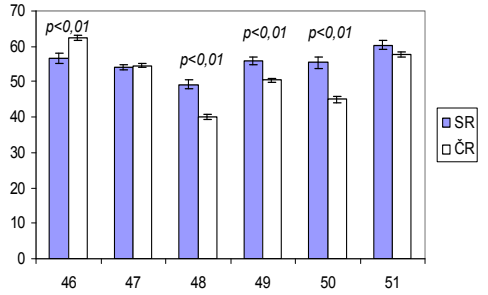


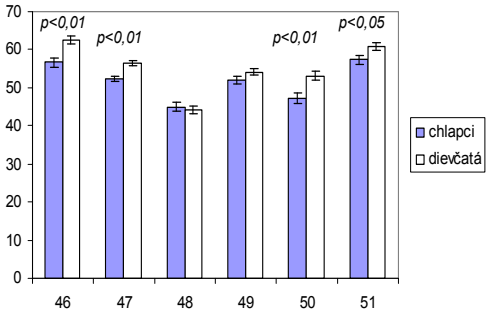
Skill 6 – Understanding the concept of numbers as…
Skill 7 – Numerical skills
Skill 8 – (data not provided)
Skill 9 – Orientation and work with the table
Skill 10 – Graphical perception
Skill 11 – Working with graphs
Skill 12 – Knowledge and work…
Skill 13 – Spatial imagination
Skill 14 – Function as a relationship between variables
Skill 15 – Logical correctness account
Level of education: 7

English language



Skill 16 – Know rhymes
Skill 17 – Vocabulary
Skill 18 – Construction of the English sentence
Skill 19 – Working with prepositions
Level of education: 7





Skill 46 – Know rhymes
Skill 47 – Construction of the English sentence
Skill 48 – Working with prepositions
Skill 49 – Working with opytovacími
Skill 50 – Responses to the simple
Skill 51 – Reading a shorter
Level of education: 5

Differences between Slovakia and Czech Republic have been inconsistent. The girls were in some cases higher scores than boys.

CONCLUSION

The aim of this contribution was to analyse the current status of that project and analysis of the achievements. Our attention, we tried to address not only the characteristics of individual stages of the project, but also the processing of statistical results and recommendations. They emerged from the experience we gained during the project, i.e. the findings of a deficit in the education of students and school students involved in the project followed the work of teaching materials and formed in early 2011 (March–May) final testing took place. When evaluating gain knowledge and skills of pupils and students will show whether the proposed methods and the curriculum effectively. Lifelong learning should be an essential part of every job seeker. This aspect is also supported by the project, which was presented in this article and which will contribute to better prepared graduates for success in the labour market.

ACKNOWLEDGMENT

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REFERENCES

[1] Hosťovecký, Marián – Zaťková, Tímea: Options for implementing videoconferencing system in a combined form of education Acta Universitatis Facultatis Paedagogicae Tyrnaviensis. Ser. C – Trnava, 2010. p. 157-164.

[2] Ladányiová, E.: National study report PIRLS 2006th

[3] Sotáková, K.: Preparing students for their future career starts at school. Proceedings of the International Conference on Gen Y enters the job market. NKOS, Trnava, 2010. ISBN 978-80-970464-3-9

[4] Law 245/2008 Z.z. on education (Education Act) and on the amendment of certain laws

Hydraulic plants for face-to-face training and remote experiments

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***Abstract*— This paper describes simple physical hydraulic laboratory models that are able to communicate with computer via both the standard USB interface and through converter cards. They show to be appropriate for evaluating different control approaches to linear and nonlinear controllers design and for demonstrating basic control features in both university laboratories as well as via Internet.**

I. INTRODUCTION

The trends in control education show worldwide increasing use of physical laboratory models. This follows from both the necessity to verify different theories in quasi-authentic conditions, by developing student's skills in such quasi-authentic environment, by meeting learning styles of several types of students and, what is also very important, by increased student's motivation to approach the theory in treating real control problems.

As it was mentioned e.g. in [7], or [11], experiments appropriate for teaching control theory should yield:

- clear physical "visibility" of the controlled dynamics,
- time constants in the range from miliseconds to minutes,
- safe manipulation,
- reasonable price of purchase or of the own development,
- availability of sensors and actuators,
- easy maintenance.

In the last years, these criteria have been extended by the requirement of

- possible approach via Internet.

This should provide an access to the experiments [13] and at the same time also develop students' skill in the use of Internet, which is becoming to be important communication and control tool.

Of course, with respect to the authenticity of experiments, these should face typical problems of controlling plants met in practice and so to enable acquisition of necessary knowledge, attitudes and skills.

Among the most popular systems used in education today one should mention hydraulic plants that are of different shapes and sizes and are distributed worldwide practically at each university or laboratory being active in teaching control theory. The broad availability, however, does not mean that all of them are equally appropriate for education.

Figure 1. The coupled-tank hydraulic laboratory system uDAQ28/2H

We have bought the first two-tank hydraulic plant (described in [13]) already in 1990. Due to some practical requirements we have started with its modifications and some time later we have started our own development. From that time we are permanently experimenting in modifying different features of our systems - by keeping in mind all above requirements on the experiments appropriate for education.

II. BASIC DESCRIPTION

Nowadays, we are working with coupled two- and three-tank plants.

Both are aimed to provide support in education and developing skills in input-output data manipulation, communication with outer computer environment, plant identification and control. They can be used to study automation, control engineering, process control and applied and industrial informatics.

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The configuration of the plant can easily be modified, for instance in Matlab/SIMULINK, by setting respective pimps, tanks and valves active or inactive. This may be used for developing broad scale of different experiments ranging from simple identification up to complex nonlinear and hybrid control applied directly in labs, or remotely via Internet.

The plant allows measuring the levels of liquid in respective tanks by means of the pressure sensors positioned at the bottom of the tanks.

III. Measurement & Communication Systems uDAQ28/2H and uDAQ28/3H

The Measurement & Communication Systems uDAQ28/2H and uDAQ28/3H in cooperation with the company Digicon and the non-profit organization E-Academia Slovaca / Slovenská e-akadémia, n.o. use own microprocessors for the data processing and communication. They can be connected to standard computers via USB port without necessity of using special converter cards and special real time control software. At the same time, they simplify the communication and control. The plants are supplied by a safety 9V and 24V voltage adaptors.

The pumps are controlled by analogue inputs 0-9V, the valves by on-off signals 24/0 V.

The levels are measured by pressure sensors 0-0.5Pa enabling individual calibration for each level, with passive temperature compensation by a constant feed current. The achievable precision better than 1% (in steady state the level varies by +/- 0,5mm).

Settling time for control processes is in the range approximately 100 s (with respect to the level change).

Matlab Communication Interface works with sampling periods 250 ms and more, whereby the serial port timeout for purpose of data readout can be lowered down to 250 ms. There is ability to raise Matlab process priority above priority of common tasks running under MS Windows.

Similarly as described in [11], [12] the build in processor avoids necessity to build a simulation scheme all the time you change it. This results in the possibility to use SIMULINK block Matlab Fcn that may contain own algorithms stored in M-file and in the possibility to adjust all communication parameters in single user dialogue window

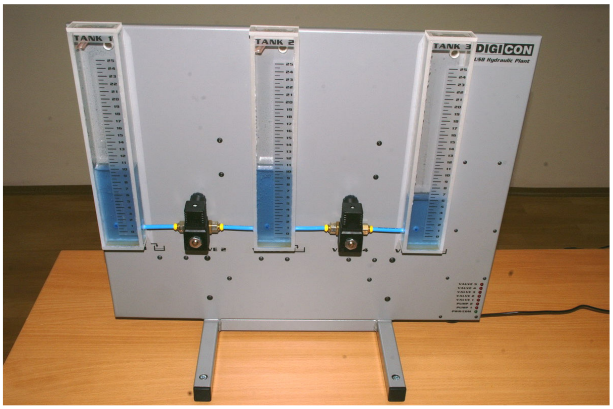

Figure 2. The three-tank hydraulic laboratory system uDAQ28/3H

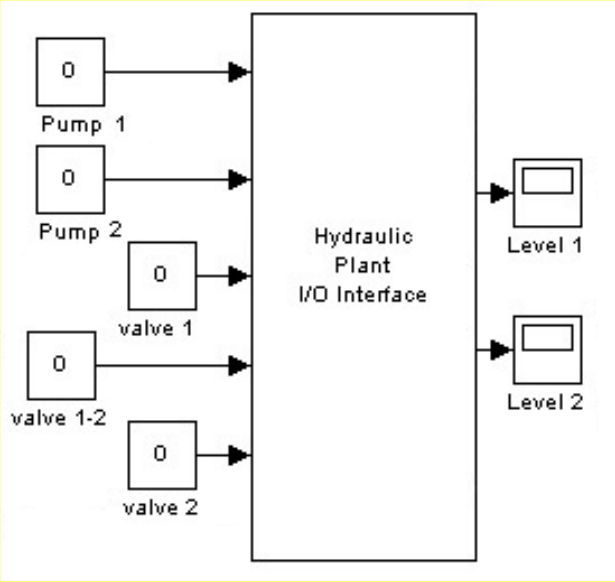

Figure 3. Simple schematic diagram of the Coupled-tank hydraulic system uDAQ28/2H in Matlab/Simulink

IV. Identification and Control Software

The developed plant includes all drivers necessary for operating in Matlab/SIMULINK where it is represented as a single block. The communication interface for the open source SCILAB is under development.

The plant is delivered together with a package of the basic algorithms for identification and control.

For calibration of level sensors and for identification of the full nonlinear model it is possible to use fully automatically running programs [19].

Programs for many tasks related to nonlinear control are available as well, see for instance papers devoted to algebraic generalized transfer functions based approaches [5], [6], [16], [17], or to design of constrained controllers for nonlinear plants of different complexity [1], [8], [18].

For organization of the study and laboratory work enables to use modern blended learning approach [9], [10], [11], [13]: after introductory preparation by the course materials in Moodle and initial face-to-face visit to laboratory, the extension module WebLab [2], [3], [4] gives to your students the 24/7 access to the plants via Internet enabling to enjoy a rich experience from controlling a real process.

V. Conclusions

The developed laboratory plants bring a revolutionary solved communication, universal connectivity to all computers via the USB port, small & handy, maintenance free, portable, easy assembly & disassembly!

Control of two or three output variables by two-eight inputs yields a broad spectrum of performances with different static, dynamic and stochastic properties.

Low price of the control system is enabled by sparing the real time control software & converters – instead of buying one traditional piece of equipment you may have plants and teachware for the whole class.

The plant offers:

- visual, quasi-authentic, simple and safety student's work environment supporting the "learning by playing", "learning by doing", or "learning by discovering" constructivist approach, motivating students for experimenting and study,
- simplified real-time control design & implementation that extends the possibilities of simulation tools and develops experimental skills required by practice.

ACKNOWLEDGMENT

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REFERENCES

[1] Bisták, Pavol: Time Sub-Optimal Control of Three-Level Hydraulic System. In: Selected Topics on Constrained and Nonlinear Control. Preprints. - Bratislava : STU v Bratislave, 2011, 175-183

[2] Bisták, Pavol: Remote Laboratory Software Module for Thermo Optical Plant. In: Selected Topics on Constrained and Nonlinear Control. Workbook. STU v Bratislave, 2011, 275-290

[3] Bisták, Pavol - Folvarčík, Pavol: Remote Laboratory Java Server Based on JACOB Project. In: International Journal of Online Engineering. - ISSN 1861-2121. - Vol. 7, No. 1 (2011), 33-36

[4] Bisták, Pavol: Matlab and Java Based Virtual and Remote Laboratories for Control Engineering. In: 17th Mediterranean Conference on Control and Automation : Thessaloniki, Greece, 24.-26.6.2009. - Piscataway : IEEE, 2009,. 1439-1444.

[5] Halás, Miroslav - Huba, Mikuláš - Žilka, Vladimír: Constrained Discrete-Time Nonlinear Controller for a Fluid Tank System. In: AT&P Journal Plus, 2 (2007). – Bratislava,. 10-15.

[6] Halás, M.: Discrete-time solution to the disturbance decoupling problem of coupled tanks. Process Control '11. Štrbské Pleso, Vysoké Tatry, Slovakia, 2011

[7] Huba, M.: Experiments in Control Education. In: CASYS International Journal of Computing Anticipatory Systems (Ed. D.Dubois) Vol. 9, 2001. - pp. 84-93.

[8] Huba, M.: Constrained Control of the Two Tank System.9th IEEE Mediterranean Conference on Control and Automation,Dubrovnik, 93-98, 2001.

[9] Huba, M.; Simunek, M.: Modular Approach to Teaching PID Control, IEEE Transactions on Industrial Electronics, vol.54, no.6, pp.3112-3121, Dec. 2007.

[10] Huba, Mikuláš - Kamenský, Martin - Bisták, Pavol - Fikar, Miroslav: Blended Learning Course "Constrained PID Control".In: Advances in Control Education 2006 : 7th IFAC Symposium. Madrid, Spain, 21.-23.6.2006. - Madrid : UNED, 2006. - CD-Rom

[11] Jelenčiak, F., Kurčík, P., Huba, M.: Thermal plant for education and training. In: ERK - IEEE Int. Electrotechnical and Computer Science Conference, Portorož, Slovenia, 2007, B: 318-321.

[12] Kamenský, M., Kurčík, P., Huba, M.: Demonstration of Integrating Thermo-Optical Plant uDAQ28/LT into Learning Process in Control Engineering Education. In: Lifelong and Blended Learning 2006 : Int. Conf. ICL Villach, Austria. Wien : International Association of Online Engineering, 2006

[13] Žáková, K., Huba, M., Zemánek, V. a M. Kabát: Experiments in Control Education. IFAC Conference Advances in Control Education ACE'00, Brisbane, Australia, Dec. 2000.

[14] Žilka, Vladimír - Bisták, Pavol - Kurčík, Peter: Hydraulic Plant Remote Laboratory. In: International Conference REV 2008 : Düsseldorf, Germany, 23-25 June 2008. - Wien : International Association of Online Engineering, 2008. - ISBN 978-3-89958-352-6. - CD-Rom

[15] Žilka, Vladimír - Bisták, Pavol - Kurčík, Peter: Hydraulic Plant Remote Laboratory. In: International Journal of Online Engineering. - ISSN 1861-2121. - Vol. 4, Special Issue (2008)

[16] Žilka, V., Halás, M.: Disturbance Decoupling of Coupled Tanks: From Theory to Practice. IFAC Symposium on System Structure and Control. Ancona, Italy, 2010

[17] Žilka, Vladimír - Halás, Miroslav - Huba, Mikuláš: Nonlinear Continuous- and Discrete-Time Controller for a Fluid Tank System. In: EUROCAST 2009 : 12th International Workshop on Computer Aided Systems Theory. Las Palmas de Gran Canaria, Spain, 15.-20.2.2009. - : Universidad de Las Palmas de Gran Canaria, 2009. - ISBN 978-84-691-8502-5. - S. 206-207

[18] Žilka, V and Huba, M: Constrained PID Control Tasks for Coupled Tanks Control. In: Selected Topics on Constrained and Nonlinear Control. Workbook. - STU Bratislava, 2011, 247-274

[19] Žilka, V and Huba, M: Laboratory Model of Coupled Tanks. In: Selected Topics on Constrained and Nonlinear Control. Workbook. - Bratislava : STU v Bratislave, 2011, 229-246

Adaptive Open Corpus E-Learning and Authoring, Using Collaborative Ontology Learning

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***Abstract*—Adaptive e-learning systems are better for achieving many learning goals, but adaptive content development is more difficult and expencive. The open-corpus model enable use and reuse of many external resources to facilitate development process and ensure well-organized actual and personalized learning content. The main idea of this paper is controlled extension of previously developed by professionals learning course in the learning process by learners. We propose conceptual model and evaluation example of adaptive e-learning system, including easy-to-use tools, allowing users to find needed in the learning process external content and adding them as semantically described new learning resources in the system. The added content may be then checked and changed by other users – learners or teachers. The system propose tools not only for finding, manipulation, annotation and organization of the new content, but it ensure the enrichment of it described schema (ontology) by using interactive ontology learning.**

I. INTRODUCTION

IMS Learning Design (IMS LD) specification has recognized as leading standard in e-learning. A large number of systems and tools for creation, publication and usage of units of learning have been developed (Moodle, Sakai, LAMS etc.). These tools facilitate student's access to learning content and activities, using Educational Modeling Languages (EML) to describe *from a pedagogic point of view* the learning design of courses. Standartization, description of learning content by usage of structured metadata, professional development of learning content and severe guidance of the learning process by professional pedagogs are in the basis of IMS – based E-learning. Despite of all this enormous and well-done work, they are not universally used, there are many learning courses, that don't use them, and many research projects, searching better solutions. Main drawbacks of standard IMS – based learning systems are:

- insufficient expressiveness of underlined XML-Schema- based metadata model;
- IMS systems are directed to the average student. Personalization capabilities are limited and rarely used;
- current pedagogical practice is still teacher-centric. The process of education is primarily institution-centric, rather than learner centric;
- the LMS is not open to activities occurring outside its realm. No support of using resources or contacts outside the system, time and labor – consuming updating of internal learning content;
- in the IMS systems supporting collaboration and communication is limited.

There are two main approaches to improve the quality of e-learning systems: by enrichment of LMS – based systems (by adding additional metadata and intelligence in structure and processing) [3], [6] and by using new open and learner – centric educational model [2]. Many projects have been developed in the last years to overcome the IMS – based system limitations by adding intelligent and semantic web technologies[1], [5], [6]. The results show some improvement, but shortcomes in communication and collaboration are still persistent. Using semantic technologies is usually domain and language specific and requires doing much specific knowledge – representation tack before achieving quality improvement. To investigate the open, Web – based educational model, several PLE (Personal Learning Environment) systems have been developed and tested [4]. Results show that they present successful solving of communication and collaboration problems, but new problems, related to quality of learning and interface usage problems have been arisen.

We believe that flexible combination of these two approaches according to learning specifics and goals are needed for development of good e-learning system. In this paper we propose conceptual model and run testing example of adaptive e-learning system, including easy-to-use tools, allowing users to find needed in the learning process external content and adding them as semantically described new learning resources in the system. The added content may be then checked and changed by other users – learners or teachers. The system propose tools not only for finding, manipulation, annotation and organization of the new content, but it ensure the enrichment of it described schema (ontology) by using interactive ontology learning.

II. E-LEARNING AND AUTHORING SYSTEM ARCHITECTURE

Our system architecture includes loosely-coupled tools for learning, teaching and authoring, proposed as

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services. It may be used in personal learning environment to ensure the arrangement of different personalized views for different users. They are intended to facilitate learning and authoring, as well as working with semantically-organized resource metadata. The system architecture is open (internet communications for finding external resources are assumed), and layered. It include four layers: User interface layer, providing interfaces for learners or teachers, Service layer, including all proposed services, Metadata and knowledge layer, and e-learning resources layer (Figure 1). The main resource development strategy assumes professionals first develop the most important learning resources for the course (Base e-learning resources layer), it semantic structure and semantic tools, and then learners are expected to use these tools to enhance learning course according ti his specific educational needs.

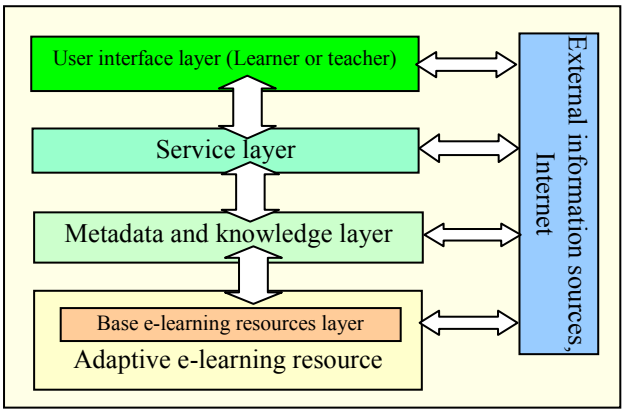

Figure 1. Adaptive e-learning and authoring system architecture

A. *User Interface Layer*

It provides interfaces to ensure easily usage of learning, teaching, e-learning resource authoring and metadata and ontology management by non-professionals (learners or teachers). This includes personalized resource recommender, ontology visualization tool, query disambiguation tool, tool, helping in interactive formal specification of the concept semantic (for supporting ontology learning process). As user may wish to use only some of the proposed tools, and different users may prefer different tools, the system should propose a also a tool for arrangement of chosen interface elements in personal working area of every user (similar to the PLE).

B. *Service layer*

The service layer includes implementation of all valuable software components, implementing the min system functionality. The system requires registration and authorized login to control the quality of the developed resources. That is why User profiles management tool is required. In case of any change in learning resources, information about this (who, and when this ss made) is stored for future analysis. Resource development is carried out by a specialized tool for this purpose (Figure 2). It sends queries outside the system (usually in the internet) for necessary resources, then calls the tools for analysis of returned results metadata, or analysis of the resources themselves (based ontologies, thezauruses, or templates, available in the system), call the ontology learning or mapping tools when needed. Currently, our system can analyze only HTML and plain text resources. Annotation tool analyze the document, determine it structure and components, using document structure ontology, may break them in smaller parts, supply parts with the required metadata and propose them to the E-learning resource development as potential further learning resources.

When new resource has been added to the system, it may be related to the concept or property, not currently presented in the domain ontology, but being in potential interest for students. In order to guarantee opportunities for expanding and deepening the larner's knowledge and support qualified semantic description of educational materials, sometimes extension of course domain ontology, in the process of training is needed. This is performed by ontology learning tool. This tool may interact to the learner, asking him about the semantic of the consept, for which he/she search learning materials(if this consept not previously included in domain ontology), and use the answers to detetermine properties and relationships of the new consept to ensure ading them in ontology. Domain thesauruses, other ontologies, or linguistic analysis of learning resources also may be used in the ontology learning process.

The Tool for developing learning resources reseive user queries, describing it needs from new learning resources, choose development strategy and query other servises for performing semantic search lexical, syntactic and semantic analysis of textual resources, classification, annotation, breaking into smaller parts, mapping or enrichment of domain ontologies (Figure 2).

All these tools are provided as a service. For the

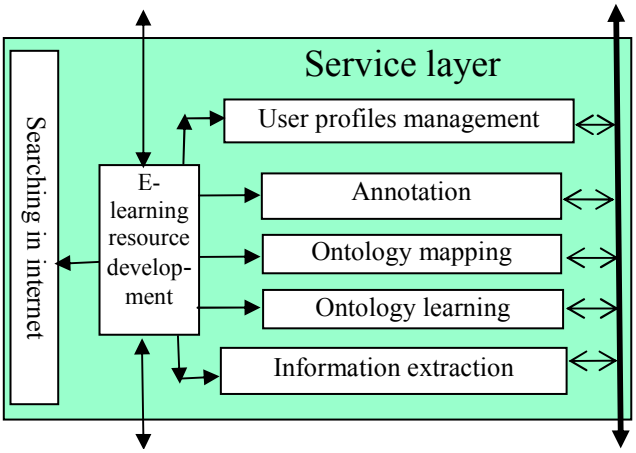

Figure 2. Main components of the service layer

overall organization of the system service-oriented architecture is used. This ensures communication compatibility and modularity at the level of communication with other systems.

C. Knowledge and metadata layer

The metadata (knowledge) level contains both semantic metadata to ensure the process of developing resources and implemented methods and algorithms for their use. Ontological representation of metadata guarantee both storing the semantic of metadata and computational reasoning on this base. To describe various characteristics of the learning materials and learning process, several ontologies are used (Figure 3): Learning content ontology, Upper domain ontology, Document structure ontology, Learner profile ontology, Learning goals ontology.

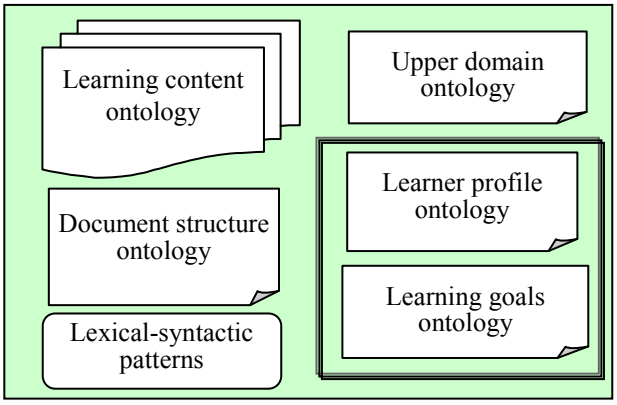

Figure 3. Knowledge and metadata layer

Learning content ontology is previously developed for each course. Therefore the system can include several such ontologies. Each of them represents essential cource domain terms and it relationships in needed granularity. In these ontologies parts of definitions and properties of learned concepts are explicitly represented in machine processable way. Every found online resource should be evaluated on the basis of those ontologies in two aspects: whether it include connections between the concepts presented in the ontology and if it contains links between some concepts that might enrich the ontology. The existence of concepts and links in the resource presented in the Learning content ontology is a criterion for thematic proximity of the resource to the course content and the presence of some new concepts and relationships offer the potential to broaden and deepen learner's knowledge. When new resources are added dynamically during learning process, they may contain consepts or relations, not included in the domain ontology. In this case, ontology learning tool analyze relations of these entities to the entities in domain ontolgy, using pattern – based text analycis and existing system ontologies and tezauruses and propose to the user through graphical interface some presumptions about possible relations. If user confirm some of them, they are added to the domain ontology. In such a way, interactive ontology learning process is performed.

Document structure ontology is used for classification of resources according to what media (text, video, audio) they contain, what accompanying metadata include (for example, information about the author, layout, use of documents (for detailed study, to define in practice .. .) or according to their style (popular science). Depending on the type of resource it could be used as part of a training sequence in a specific place for a particular purpose or user.

Upper domain ontology is useful in many cases for identifying closely-related domains, and making rapid conclusions if returned material may be in potential interest, or not. It also is used when for finding interdomain relationships, and in some other cases.

Pedagogically-rich ontologies as Learner profile ontology or Learning goals ontology include knowledge about the learner, or pedagogy, needed for optimal organization of the learning and teaching process, or supporting development of the high quality learning resources. Learner profile ontology may contain classifications of learning styles, learning problems of the groups of learners, that can be used for annotation of resources according to the learner type, for which they are designed

Lexical - syntactic patterns are important in the machine analysis of natural language text to automation of the processes of learning resource development. They can be used in conjunction with semantic knowledge represented in ontologies in the process of identification and categorization of text resources.

D. Learning resource layer

The level of educational resources include developed resources repository. The main resource development strategy assumes professionals first develop the most important learning resources for the course (Base e-learning resources layer), and then learners are expected to enrich learning course materials in the learning process according to his specific educational needs. The main goal is to achieve the maximum possible degree of automation using metadata and semantic web technologies. The main source of materials for resource development is internet, and search engines are used to find needed web resources.

III. TESTING EXAMPLE – DEVELOPMENT AND EXTENSION OF E-LEARNING COURSE IN PROGRAMMING ENVIRONMENTS

Motivation of this work comes primarily from practice. We first have developed a small system for to assist students in lerrning programming environments, then increase it functionality and flexibility, adding semantic representation of metadata, and semantic tools. Finally we develop an above model to explain it architecture from more abstract point of view, make general conclussions and discuss possibilities for use this architecture in other domain or other learning scenarios. For initial resource development we use HTML and JavaScript. Then we divide large resources intended to support learning MFC programming to smaller parts and present new course organization, using terminology

classification by developing OWL ontology. Initial version of this ontology is shown on Fig. 4.

Writing effective working programs, using MFC require excellent knowledge and programming skills in basic C programming and object – oriented programming. Our students are studying these courses, but some of them proved to have significant gaps that need to fill, seeking materials from various sources, which takes a long time. To cope with this problem, we use Java servlets and Tomcat to add some assistence in

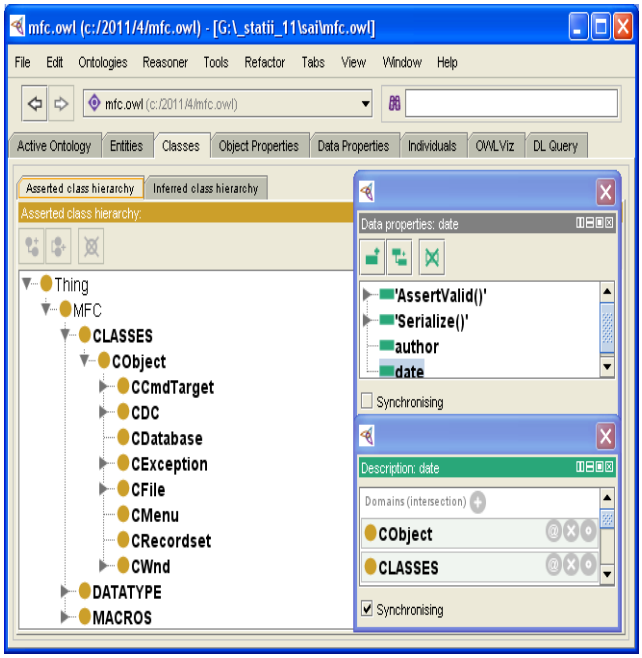

Figure 4. Initial version of domain ontology

writing clear and unambiguous queries for effective web search, Java and WordNet libraries for development of tools, making lexico-synthactic text analysis, Jena and Protégé API for development of ontology – based annotation tool, omtology mapping and ontology learning tool. Really, this take a lot of time, but not so much, because we have found a lot of free source code, writing in Java, and it modification comes sgnificantly easy, than writing all code from scrach. We write only initial working versions of these tools and run them on our small example. On the future, they may be optimized, if better performanse or precision are required. Despite of fact, that programs are written and used in the domain of programming environment, the main part of softwere is domain – independent, and after after minor changes may be used in learning systems for other domains. Only initial version of MFC ontology must be completely replaced by the semantic description of the terminology of the other learning domain.

In the interactive ontology learning process to facilitate domain ontology enrichment we use Web information sources: Glossary of Programming Terms Used in C++ (http://www.steveheller.com/ glossary.htm) and http://www.abbreviations.com/. To extract needed relationships ftom the first resource, we use lexico-synthactic patterns. The second resource is useful in determining the possible meaning of abbreviations, sa they are frequently used in the programming and computer science domain.

IV. RESULTS AND STUDENT'S OPINION

We evaluate our system by proposing it to the students, write all them activity and analyze it after finishing the course of programming environment and examination. On fig. 5 the screenshot of the domain ontology at the end of the course, opened in protégé is shown.

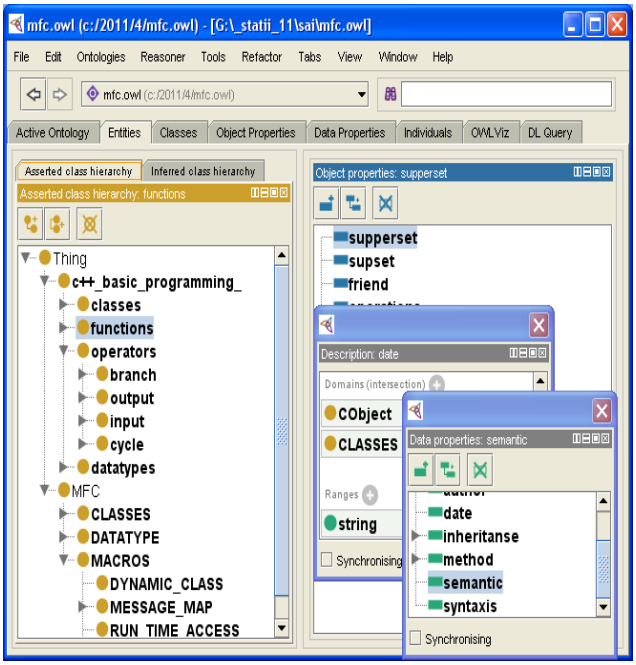

Figure 5. Domain ontology at the end of course

29 of all our 41 students (71%) are participated in adaptive resource development or ussage of developed by other student resource process. Individual participation of every of these students is illustrated on Fig. 6, where are sorted by final examination results. 19 students (46%) participate in interactive semiautomatic ontology

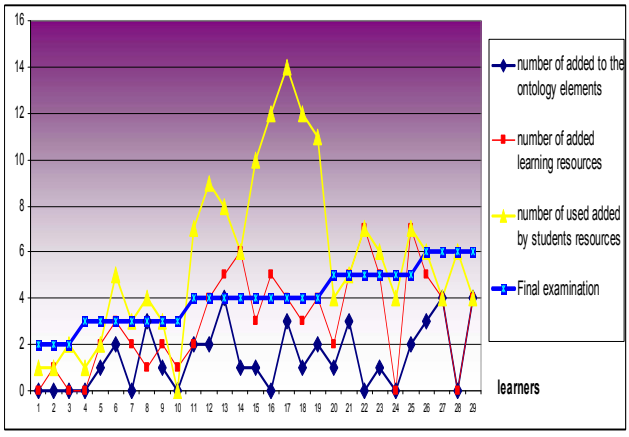

Figure 6. Student's results, resource development and usage

development, adding 41 entities. 87 new adaptive

learning resources are added, mainly to support revision of studied before material.

As may be seen on fig. 6, the most frequent usage of adaptive resources is in group of students, achieving good results. This can be explained by the fact, that they are hardworking, but have some gaps in previous training. For teaching this group, such adaptive e-learning system is the most useful, because excelent students have lower need in searching remembering resources, and weak students doesn't work very hard (may be). Excellent students use at average 5 adaptive resources each. At about a half of these materials discuss knowledge, out of range of previously attended courses.

To obtain student opinion about the system and its features, we present a non-mandatory questionnaire at the end of the course. 37 of our 41 students filled in the questionnaire. 98.% of them were active users. Overall results are illustrated in Figure 7. 96% of the students agree that adaptive resources are useful in learning. 12 % agree that ontologies are useful in learning, but 70% find difficult ontology development. Having in mind the fact, that we present an interactive ontology development interface, maximally hiding the details of knowledge representation, we conclude, that courses on working with knowledge and representing data at semantic level (using semantic web technologies and machine reasoning are needed to be included in the university education to make these modern and perspective technologies more understandable for educated peoples.

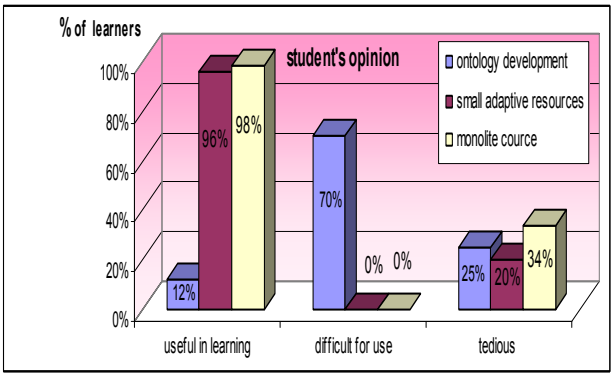

Figure 7. Student's opinion

V. CONCLUSION

In this paper we present an adaptive e-learning resource parallel usage and enrichment approach, based on semantic technologies. Our approach successfully combines professional e-learning resource development and collaborative personalized enrichment at the stage of it usage. Adding of new resources to the e-learning course in general leads to usage of extra concepts or relations that are not included in the domain ontology, describing the course semantic. That is who if we give to the students the opportunity to add new teaching materials in the course, we should provide tools to automatize their semantic description (semantic annotation) and to extend the course schemma (adding new concepts in the domain ontology). Our test case in the domain of programming environments, using MFC show that combining some natural language analysis and ontology learning techniques may facilitate interactive ontology enrichment and make possible some semiautomatic extension of e-learning course, adding personalized and adaptive content. The quality of developed in such a way resources should be controlled by professionals, but they certainly are useful in three aspects: helping professionals better understanding learner needs, saving time and efforts in searching and analyzing external materials, and promoting active participation of learners in the process of learning and resource development.

VI. REFERENCES

[1] R. Amorim, et al, "A Learning Design Ontology based on the IMS Specification". IEEE Journal of Educational Technology Society, volume 9, number 1, 2006, pp. 38-57.

[2] S. Downes, "The Future of Online Learning and Personal Learning Environments", From http://www.slideshare.net/Downes/the-future-of-online-learning-and-personal-learning-environments, 2007

[3] "IMS LIP. IMS learner information package specification". Available at: http://www.imsglobal.org/profiles/lipinfo01.html., Accessed on April 20, 2011

[4] T. Martindale, M. Dowdy. "Personal Learning Environments". In Veletsianos, G. (Ed.), Emerging technologies in distance education, 2010, 177-193.

[5] D. Milosevic, C., Sukic, R., Sendelj. "Ontology-based Learner Modeling in Intelligent Tu-toring Systemsby". Technics Technologies Education Management Ttem, Volume: 5, Issue: 2, 2010

[6] J C. Vidal, et al,. "OPENET LD: An Ontology-Based Petri Net Engine to Execute IMS LD Units of Learning". Ninth IEEE International Conference on Advanced Learning Technologies, 2009

Borderless education with high speed networks

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***Abstract*—Information and communication technologies have connected and brought people together in several ways. In the last decades, the way people were able to communicate and exchange information has changed everything. As the Internet started to grow, the IP protocol became the de facto standard in networks, more and more applications have started their journey to bring faster, more reliable and powerful communication and collaboration mechanisms to people all over the world. First it was just an E-mail, then Instant Messaging as a way to quickly discuss things, later real-time and live Voice over IP. Currently a new phenomenon is being seen and it is real-time Video and Voice over IP. By 2014, video is predicted to form 91% of the global Internet traffic. The power of video is in face-to-face communication, emotions, gestures, body language, etc. The paper shows how the e-learning can be transformed from only reading online content into studying online using advanced videoconferencing – TelePresence. It is based on a case study on using Cisco TelePresence at the Technical University of Kosice (TUKE), Slovakia, Europe and at Paradise Valley Unified School District (PVUSD), Phoenix, Arizona, USA to develop and provide a course that is held by an instructor located at TUKE to students located at PVUSD.**

I. INTRODUCTION

The educational process has not been significantly changed in the last 2000 years. The biggest change happened only to books. These books have moved from the form of printed black and white papers to colored textbooks and nowadays to online content. This way the e-learning was born. The online content can contain several multimedia and interactive parts, which make the learning process of students much easier and more effective to understand. While the books have innovated themselves, it was always about a single teacher who has delivered the knowledge to students.

In some geographical areas it might be impossible to hire a local teacher who will be skillful enough to teach complex systems to local students. Rural areas outside of major cities are affected the most by this issue. When this issue is not addressed, rural areas are unable to grow and transform into new, highly prospective areas simply because of the lack of knowledgeable workforce.

Teaching advanced topics might be challenging in any area. Especially topics that are connected with technology. Technologies are changing and more importantly growing so fast, that one cannot be an expert forever in several fields. Schools must seek for the new best experts in those fields, who can deliver the knowledge to students in the best possible way. This is a difficult job, as those experts are many times either already working in different institutions, or are located in different cities. Although many schools nowadays do so, daily transportation of shared staff members or students between schools and/or institutions can be really exhausting and thus ineffective. People are losing expensive time during traveling and exhaust gases from vehicles are not helping our nature either.

As the speed of the Internet and its penetration is growing faster every year, it affects more and more people. New applications are being developed that make the daily life easier. Like communication through e-mails has totally changed the way business works and transformed formal letters to something that looks more like instant messaging, real-time communication applications are changing absolutely everything. Real-time Voice over IP has enabled families to have long lasting conversations with their friends and brought back people from far to closer. Lately video communication is believed to be the biggest gamechanger in real-time communications. Some predictions say that by the end of 2014 all video content will exceed 91% of the global Internet traffic [1]. The great importance of video is in visible emotions on face-to-face communication, body language, gestures, etc. Researches in the area of human communications show that more than 60% of all communications are derived from nonverbal behavior.

Real-time face-to-face video communications through videoconferencing applications are nowadays available to everyone on the Internet. Many of those applications are not providing any guarantee of quality of service or quality of experience. While for home use, that aspect might be acceptable, for enterprises the demand on the quality of experience is much higher. Therefore, for enterprise video communication the TelePresence technology should be used.

TelePresence is not just a simple videoconferencing solution. TelePresence refers to a set of technologies which allow a person to feel as if they were present in the same room. Video is delivered in Full High Definition 1080p resolution, while every participant has its own place at the table which is captured and displayed at the other end in real life-size. Eye contacts, as well as gestures on faces and emotions are experienced the very same way as in real life. The TelePresence room is equipped with special sound and lighting technique, which is automatically adjusted in a way that people in the room are not perceiving TV screens, but people on the other side of the "virtual" table.

II. CISCO TELEPRESENCE [2]

Globalization increases the need for communication among colleagues and partners. Business discussions encompass not only multiple people but also multiple locations.

While today's meeting and collaboration tools provide a significant productivity boost, they are not a substitute for in-person meetings. Videoconferences, in particular, are often difficult to set up, challenging to use, and do not

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adequately replicate the benefits of face-to-face interaction.

To improve this situation, Cisco TelePresence creates an "in-person" meeting experience over the converged network. Cisco TelePresence delivers real-time face-to-face interactions between people and places in their work and personal lives using advanced visual, audio, and collaboration technologies. These technologies transmit life-size, high-definition images and spatial discrete audio. Now it's easier than ever to discern facial expressions for crucial business discussions and negotiations across the "virtual table."

Figure 1. Cisco TelePresence effect – the virtual round table

A. *Audio/Visual Technology*

Cisco TelePresence incorporates the latest standards and technologies to offer the best audio and visual results:

- H.264 video codecs to offer the highest quality and lowest bit rate
- Session Initiation Protocol
- Native 720p and 1080p high-definition cameras
- Native 720p and 1080p high-definition encoding/decoding
- Low-latency architecture and low bandwidth utilization
- Wideband advanced audio coding with low delay (AAC LD)
- Multichannel spatial audio with echo cancellation and interference filters to eliminate feedback from mobile devices
- Optimized environmental conditioning to provide the best audio and video and overall user experience

B. *Network*

Cisco TelePresence uses the standard IP technology deployed in corporations today and runs on an integrated voice, video, and data network. The system supports high-quality, real-time voice and video communications with branch offices using broadband connections.

It offers capabilities for ensuring quality of service (QoS), security, reliability, and high availability for high-bandwidth applications such as video — particularly high-definition video, which can require 1 Mbps to 5 Mbps, depending on the resolution.

C. *Hardware-Optimized Environment*

The system includes purpose-built office furniture that incorporates cameras and displays, lighting, speakers, microphones, and projection capability into a specially designed table for larger rooms, or, in smaller configurations, into existing office furniture.

D. *Software Applications*

Cisco TelePresence applications incorporate a variety of new and existing standards-based software for accommodating converged voice and video transmissions, including:

- IP telephony
- Groupware
- Services

E. *Cisco TelePresence at the Technical University of Kosice[4]*

The Technical University of Kosice (TUKE), one of the key leaders in Slovakia in the field of introducing new, innovative forms of communication into educational processes and work with students, has installed its own Cisco TelePresence CTS-3010 room in May 2010. This was the first installation of Cisco TelePresence CTS-3010 in an educational institution in the region of Central Europe.

The Cisco TelePresence unit at TUKE, as well as at other Slovak universities, is connected to the Slovak Academic Research Network (SANET) which provides a 10Gbps optical backbone network, with interconnections to CESNET and GEANT2 networks. As the backbone is highly over-provisioned, currently it was not necessary to implement QoS mechanisms into the network which simplified the Cisco TelePresence installation processes.

Cisco TelePresence virtual meeting solutions are designed to provide users with the feeling that they are virtually in the same room together. To achieve this level of realism, certain conditions must be met:

- To present a life-like, high-definition image of a person in real-time over the network requires very stringent service level requirements for delay, delay variation (i.e. jitter), and packet loss.
- The meeting room environment also must provide a near perfect replication of lighting, acoustics, and ambiance.

The Cisco TelePresence unit at TUKE has passed all the required conditions and TUKE has received a certificate of the Cisco TelePresence eXperience. CTX is a mark of excellence in a new and growing TelePresence industry.

III. TELEPRESENCE NETWORKS

Having a TelePresence unit without a possibility to connect to other units would be pointless. Therefore several commercial TelePresence network operators exist

around the world. These networks are private, closed networks, that guarantee QoS service level agreements. For the real experience of TelePresence calls it is always necessary to have enough bandwidth with short delay and jitter between the endpoints. The private operator provided TelePresence networks can provide that requirements. On the other hand, as these networks are closed, not publicly accessible, there is a limitation on interconnection and less possibilities on creating TelePresence calls between different organizations.

While the public Internet does not guarantee any QoS parameters (as the communication might be routed from the source through several different Internet Service Providers towards the destination), interconnections between National Research and Education Networks (NREN) are well distributed and provide enough, usually even over-provisioned bandwidth.

In the USA, the National Lambda Rail (NLR) NREN operates a public Cisco TelePresence exchange that is used to cross-connect TelePresence units in education [3]. Currently there are more than 60 Cisco TelePresence units from the USA connected to that exchange point [9]. It enables all those units to communicate with one another. TUKE is connected to the very same exchange at NLR, thus making TUKE reachable from any USA Cisco TelePresence unit and vice versa. Even though the data communication from the TUKE TelePresence unit is flowing generally through the public Internet (SANET-GEANT2-NLR), with current TelePresence calls there were no QoS related issues detected by the time of writing this paper.

IV. CASE STUDY OF TELEPRESENCE USAGE AT SLOVAK UNIVERSITIES

A. The TelePresence portal

The TelePresence technology is a fairly new way to communicate with people over long distances in very high quality. Many people are not familiar with this technology, which is caused by the lack of information in the local environment. Therefore, a new informational portal has been developed to provide everyone with basic information about the TelePresence technology. The portal not only provides basic information for the general audience, but also provides information for scheduling calls, checking calendars, etc.

B. Connecting Cisco TelePresence sites together

In bigger TelePresence networks and exchanges [3], the network operators are using a Session Border Controller device which provides a single point of connection for every participating TelePresence site. In the National LambdaRail TelePresence network (NLR) in USA, they were using a Cisco GSR router with an SBC blade in it that can provide such a functionality needed for TelePresence interconnections. Currently, they have moved to Cisco's ASR routers, which are now the preferred platform to be used as an SBC [1]. With a lack of these devices either in SANET, or at TUKE, other methods to interconnect TelePresence systems in Slovakia were researched.

With great experiences from a successful deployment of VoIP networks in a Slovak educational field, it was clear that other solutions can be used as well, at least to overcome the time until a new enterprise SBC can be obtained. The VoIP network between universities, high schools and other institutions was built using the SIP signalization protocol. Experiences with centralization of the VoIP call processing and call routing using open source SIP proxy servers and protocols like ENUM were utilized to provide a similar functionality as an enterprise SBC can provide.

Cisco TelePresence systems are using the standard SIP signalization protocol [10] to establish, manage and tear down TelePresence calls. Therefore, it is possible to use a standards based SIP proxy server to provide a central point for SIP based signalization routing. From the configuration point of view, for all new TelePresence sites at Slovak universities, it is enough to configure a new SIP trunk to the TelePresence SIP Proxy server from the Cisco Unified Communications Manager (CUCM) interface.

The central TelePresence SIP Proxy server was built at TUKE using a Kamailio open source SIP proxy server on an Ubuntu Linux 10.04 server installation. The configuration was updated to provide the needed functionality – to forward SIP messages to the called TelePresence site (CUCM). In the current setup, each site is manually defined with its TelePresence number in the full E.164 form (e.g. 421556027000) and the corresponding CUCM's address. Future plans are to move these parameters into a relational database, thus making afterward changes easier and less error-prone.

Now, when a user dials a TelePresence number from his room, the initial SIP messages are sent from his CUCM to the TelePresence SIP Proxy server which is then forwarding the signalization messages towards the corresponding CUCM. While all the signalization messages are flowing through the TelePresence SIP proxy server, the media stream is forwarded directly between the TelePresence units. Of course, this setup has both advantages and disadvantages. The advantage is in lower latency which is a crucial QoS parameter for TelePresence calls. The disadvantage is in the fact that in this setup, the TelePresence unit itself must provide non-firewalled connection for the media streams (which can be handled and secured using an application layer firewall with SIP inspection and dynamic port pin-holing).

C. Scheduling

The great advantage of Cisco TelePresence is its ease of use. In enterprise installations, users can schedule a meeting via TelePresence the very same way they were used to schedule normal meetings. They can use Microsoft Outlook to make a reservation for a single or multiple TelePresence rooms. The Cisco TelePresence Manager (CTM) will enable to use only a single touch on the TelePresence's IP Phone to start the scheduled TelePresence conference. This setup requires having a Microsoft Exchange installation with other supporting systems as well, which was not the case for TUKE.

From the beginning, the TelePresence room at TUKE was scheduled using Google Calendar with Google Apps. Google Calendar with Google Apps provides an easy way to schedule company resources such as rooms, places, etc., with a possibility to federate and delegate user roles on the calendar to anyone who has a valid Google account. That allowed for all new TelePresence sites at Slovak universities can use one unified calendaring

application that is available to everyone trough a web browser. With one unified calendaring application, it is now very easy to schedule a conference between institutions. The single touch dialing option, which is available with CTM, is a very popular feature not to implement. The single touch dialing was created as speed dial on the TelePresence's IP Phone menu. When users press the SCHEDULED CONFERENCE menu, the scheduler's number is dialed out. The scheduler is an application running inside of an Asterisk VoIP server, which used as a frontend for the scheduler. Asterisk provides voice guidance and assistance for the scheduled conferences. The scheduler application uses Google's DATA APIs to check for planed conferences in Google Calendar at that time and manually starts the planed conference at the TelePresence system.

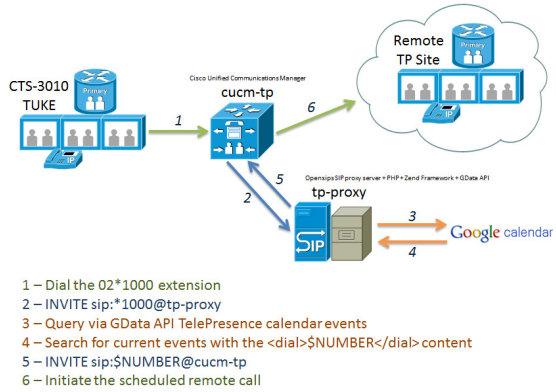

Figure 2. Single touch dialing with Google Calendar

The current version of the scheduler can even work with no touch at all, as it automatically starts the scheduled conference 5 minutes before it is supposed to start. Participants just enter the TelePresence room and the conference starts without the need for any intervention from their side.

D. Teaching@TelePresence

The Computer Networks Laboratory (CNL) [5] at TUKE is operating the Cisco TelePresence unit at TUKE, as well as developing new development activities around the technology. One of the first development activities was the interconnection between the TelePresence unit at TUKE and the NLR network in the USA. Based on this interconnection, more than 100 USA TelePresence units, which are distributed over various universities and other edu-institutions, have become reachable for employees and students of TUKE with a simple press of a dial button on an IP phone of the local TelePresence unit at TUKE.

During the summer holidays, representatives of CNL and TUKE have exchanged contacts and started TelePresence discussions with the representatives of Paradise Valley Unified School District (K12), Phoenix, Arizona, USA (PVUSD) [8]. After few e-mail exchanges and settings up a TelePresence call it was clear that both sides have strong enthusiasm and potential to start a common cooperation in both education and research and development. TUKE has presented its faculties, their activities in the field of education and R&D. All those discussions have led to the creation of a first ever global intercontinental educational program, which is provided and delivered in a form of presentation lectures through Cisco TelePresence!

Figure 3. TelePresence session between Slovakia and USA

The course contents have been developed and realized by the Cisco Academy (CA, ASC, ITC, NRP) [7] at TUKE and it provided the students and staff members of PVUSD with education in an internationally certified course called CCNA Exploration.

The development of the course with methodology, materials, etc. raised up several questions and challenges. It was necessary to deal with and find optimal solutions for the time zone difference, which in this case was even 9 hours, language barriers, but the most important was to find a good methodology and workflow on how to provide such a course over TelePresence. While the Cisco TelePresence solution provides a form of a virtual round table, compared to a class-room or a laboratory it misses, for example a whiteboard. However, whiteboard is essential for education. It enables to effectively present ideas that the teacher is trying to explain to students and thus improve the process of learning.

The summer holidays were full of work at CNL and RCNA at TUKE. Members were working together on the development of appropriate teaching methodologies for a course that is delivered over TelePresence. Within few weeks, all the new challenges that were raised with the innovative Teaching@TelePresence course were successfully solved. A study schedule has been developed based on the experiences from long-term teaching of local students at RCNA at TUKE. Also a methodology to provide lectures and exercises, workflow on how to collaborate and communicate between instructor and students, knowledge evaluation through exams, etc. were introduced. The whiteboard issue has been fixed by a "virtual" whiteboard in the form of a tablet PC with a touch screen that provides the very same ease of drawing diagrams, topologies, notes, etc.

As the first course, that was used as a proof-of-concept and as a verification of the viability of a Teaching@TelePresence course, a course from RCNA's portfolio was selected - CCNA Exploration - Network Fundamentals.

The CCNA Exploration - Network Fundamentals course is one of the most desirable courses that are available in the Cisco Networking Academy (NETACAD)

and it provides the fundamental basics that are essential for further education in the field of computer networks. The selection of this particular course was highly influenced also by the lack of NETACAD in the near locality of PVUSD, while PVUSD has expressed high interest in such a course to educate their students and staff members in the area of computer networks.

The first Teaching@TelePresence course was attended by staff members of PVUSD from various departments. In total, from PVUSD, 10 people from 5 different physical locations (always a pair of 2 persons), through 5 TelePresence units have joined the course. In order to connect to one TelePresence call all those units at the same time, a "Meet-Me" number at the NLR's Cisco TelePresence Multipoint Switch was used [2,3].

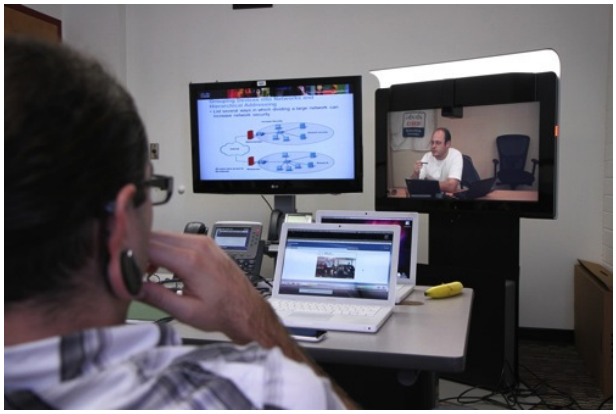

Figure 4. PVUSD Cisco TelePresence unit

Each of the 5 physical locations at PVUSD was equipped with the Cisco TelePresence CTS-500 model, which offers one Full-HD plasma screen to display the teacher, and one LCD screen to display the presentation or the "virtual" whiteboard.

Figure 5. TUKE Cisco TelePresence unit

At TUKE the Cisco TelePresence CTS-3010 offered 3 Full-HD plasma screens to display students from PVUSD and one LCD screen to display the presentation and the "virtual" whiteboard.

The schedule divided the course into 8 days in total, throughout 2 weeks [6]. Classes were held every week from Monday till Thursday. To overcome the issue of time zone differences, both parties have selected the most suitable time to start the course. Every day, the classes started at 4:00PM local time at TUKE and 7:00AM local time at PVUSD, and ended at 8:00PM local time at TUKE and 11:00AM local time at PVUSD. Each session lasted for 4 hours and ended with bon appétit to lunch at PVUSD and bon appétit to dinner at TUKE ☺

V. FEEDBACK FROM THE TEACHING@TELEPRESENCE

The practical outcomes of the course showed that the Teaching@TelePresence is a very viable way to teach remote distant students and in some ways the students and the instructor evaluated the course as even better than a course in a real classroom.

The lectures and the exercises of the CCNA Exploration Network Fundaments course via TelePresence differ only a little from a real, normal in-class teaching and learning. The teacher of the Teaching@TelePresence course can see the students in their real life-size, he registers emotions on students' faces, gestures and general body language of students sitting on the other side of the world! Hence he is able to respond with the same reaction to, for example gestures from students which might indicate difficulties with understanding of the just explained topic, as if really sitting together in one classroom. Students can interactively ask questions or add comments in the very same spontaneous manner as in a real classroom. They can even be polite and raise their hand before asking a question, as in a real situation ;-)

A. *Feedback from Students*

TABLE I.
EVALUATION QUESTIONS

Question	Average Rank (min=1, max=5)
Understanding of an instructor via TelePresence vs. via normal in-class training	4.86
Interactivity of the course via TelePresence vs. via normal in-class training	4.00
"Falling asleep" or feeling tired in course via TelePresence vs. via normal in-class training	2.71
Ease of use of your TelePresence installation (calling in, connecting a PC, sharing a screen, etc.)	4.71
Sound quality in your TelePresence room	4.86
Video quality in your TelePresence room	5.00
Presentation screen quality in your TelePresence room	5.00
Sitting in a TelePresence room vs. in a normal classroom	4.71
What is your over-all satisfaction with the first ever Teaching@TelePresence course?	5

What do you think, what is the biggest difference between a course that is via Teaching@TelePresence and a normal in-class training with local instructor?

- I don't see a big difference at all. It feels as though the instructor is in the room with you and there is no disconnect between the students and teacher. I felt more comfortable in this setting than in a face-to-face setting.
- It's easier to attend! I like that I'm not in a room with a bunch of other students.
- Not consistently seeing other participants in the class.
- the biggest different i felt was trying to answer questions since one doesn't see everyone and doesn't know if you are talking over them or not.
- No difference

- There are alot less distractions via TelePresence since there are not that many people in the room.
- That more of the students had access to a high quality instructor.

Are there any advantages or disadvantages of a course that is going through TelePresence over normal in-class course? Please express your thoughts.

- I think the advantages far outweigh disadvantages. I have taken many, many classes over my educational career and I got more out of this class than any other class.
- No.
- I like the TelePresence because it gives us more options of training outside our organization. We don't have qualified staff to teach all subjects.
- some advantages would be the fact you can take courses outside the realm of what the school may have to offer you at their campus.
- No traveling
- The only disadvantage i can see is getting face to face time with the instructor.
- I do not feel there were any disadvantages, at least in a course on this topic.

Would you attend another course over TelePresence?

- 100% YES
- 0% NO

Would you rather attend the next course over TelePresence or in-class?

- 100% TelePresence
- 0% In-class

Why did you choose that answer in the previous question? What is better/worse in that type of training?

- The TelePresence was easy to attend and pay attention to while sitting in class with a face-to-face instructor can be tedious and boring.
- I like being in a small class and not having to deal with other students. Because sometimes other students are unmotivated and distracting in a traditional classroom environment.
- In the TelePresence class there are less distractions from a regular class.
- i feel that the TelePresence was an effective way of learning, and also convenient for my situation.
- Not having to travel
- I am distracted very easily and being in a small room with only one other person helped me focus
- TelePresence was much more convenient.

Have you noticed any cultural differences between the people from the EU/Slovakia/Kosice/Technical University of Kosice/Computer Networks Laboratory+Regional Cisco Networking Academy and the US culture? Anything shocking or interesting?

- Not at all. I came into the TelePresence with an open mind and did not notice any cultural difference in the least.
- Not really... I found both instructors to be very friendly and a pleasure to work with and learn from.
- We differ on what some items are called. Nothing shocking. I like the differences.
- i have done a lot of travels throughout the world so i couldn't really say anything shocking or interesting. i have been impressed on the quality of english over there.
- No
- They need to get Macs.
- Yes. Your sense of humor, voice inflections, accented words and syllables, pauses during speech.

VI. Conclusion

Technologies are changing and transforming the world. Education is part of that change. Education as we have known it is changing and transforming the way teachers do teach students and the way students learn from teachers. Nowadays we can easily deliver knowledge to any distant place in the world. The form of the delivery, speed and quality is dramatically shifting forward for a better tomorrow. We do not have to reinvent education, but we can dramatically improve its delivery.

A good example of this shift is the example of how simple TelePresence solutions can change the way schools will seek new teachers, change the way students will interact with the teacher and in the end change everything – to better.

Together we are more powerful than we ever could be apart! Together we can change everything.

References

[1] http://www.cisco.com [15.9.2011]
[2] http://www.cisco.com/go/TelePresence [15.9.2011]
[3] http://www.nlr.net/TelePresence-faq.php [15.9.2011]
[4] http://www.tuke.sk [15.9.2011]
[5] http://www.cnl.sk [15.9.2011]
[6] http://go.cnl.sk/TelePresence_schedule [15.9.2011]
[7] http://cisco.tuke.sk [15.9.2011]
[8] http://www.pvschools.net [15.9.2011]
[9] www.wolftech.ncsu.edu/TelePresence/directory [15.9.2011]
[10] J. Rosenberg, H. Schulzrinne, G. Camarillo, A. Johnston, J. Peterson, R. Sparks, M. Handley, E. Schooler. 2002. SIP: Session Initiation Protocol, RFC 3261

Acknowledgment

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Hardware-software complex "Dashpoint" for learning and communication of deafblind people

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***Abstract*—This paper describes the project "Dashpoint". Dashpoint is a hardware and software system designed to make e-learning possible for the hearing and visually impaired. The system will also increase the communication capabilities for these specific types of disabled people.**

I. INTRODUCTION

E-learning is becoming more and more popular: a large number of e-learning management systems and e-learning courses have now been developed in various fields. Major vendors and universities are using e-learning within their curricula.

E-learning is widely used in many areas. However, there is a special category of people - disabled people - for whom e-learning is often the most appropriate option in many types of educational establishments and organizations. Among these people with disabilities are the visually impaired and this group occupies a special place. These people have particular learning difficulties and needs. There are many different methods used to convert training materials into an audio format. However, there is still a huge problem when attempting to train people with multiple disabilities such as deafness, especially when this is coupled with visual impairment. These people more than any others are cut off from the outside world. Normal communication is a difficulty they encounter on a daily basis and any form of training becomes a long and complicated process. Overcoming this handicap has been a major source of concern and has required a huge amount of research.

According to the British organization Sense [1] at the present time within the United Kingdom there are about 356,000 people who are both deaf and blind. According to the American Association of the Deaf-Blind [2] the number of such people in the USA is approximately 700,000. There are no such statistics available in many countries of the EU, because these countries do not consider deaf and blindness as an independent constraint. In Asian and African countries, statistics are not readily available. The statistics prove there are huge numbers of people afflicted in this way around the world. The massive problem of integrating these people into society is becoming very serious.

This project provides deaf and blind people with new opportunities. The ability to communicate with people who have similar disabilities: as well as, with people without physical limitations; whilst being allowed equal opportunities to learn. The project is based on communication and the perception and use of tactile sensations - vibration.

II. EXISTING SOLUTIONS

For teaching blind and deaf blind people there are various tools, both classical and modern. The classic tools include books in Braille and modern - Braille printers, Braille displays. However, these tools are not without their drawbacks. Braille books are expensive and typically do not contain more than 200 pages, besides the amount of information per page is much smaller than normal books. Therefore the Braille book contains relatively little information when compared to the same book written for the able bodied.

Braille printers are devices that connect to a PC. They can print Braille on plain paper. Such devices are manufactured by several companies and are quite expensive, the typical price of a Braille printer would be in the region of $ 6,000.

Also on the market are Braille displays. These are devices that use a special panel that simultaneously displays Braille characters 20-40 in one row, providing the user with limited vision and the possibility of a relatively comfortably to read text. However, such devices are very expensive; typical prices for the monitor are $ 2,000 per unit for a 20 display character and $ 5,000 per unit for a 40 display character.

The main restriction of the above devices is the expense of buying these devices, especially for the developing countries where people with visual impairment are not able to afford these devices for personal use. The high cost of Braille Monitors is largely due to the complexity of mechanical design, which includes a plurality of electric motors to the rods, forming a prominent point in the working field monitor.

The idea of using vibrations to transmit information to deaf and blind person in itself is not new, there are a few devices using vibrations. For example: application Nokia Braille Reader [3], by which the deaf and blind user can read a SMS on his Nokia mobile phone running Symbian. There is also the development by Indian engineers, as described in [4], which is a controller-glove worn on the hand. inside the controller a 'Vibro' is located on the tips of the user's fingers.

Using the 'Vibro' instead of advancing the rods to form Braille letters in the alphabet allows us to produce a much more compact and above all else, is a cheaper substitute for Braille display, which will be available to users with limited budgets.

We apply methods for transmission of information using vibration devices that are based on two types: regular joystick controller and our own controller Vibro6.

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III. METHOD FOR TRANSMISSION OF INFORMATION AND GENERAL CHARACTERISTICS OF SOLUTION

For the blind and the deaf people, the basic and most natural way to get information is to read using the Braille alphabet. Every character in this alphabet is a set of six dots arranged in 3 rows and 2 columns. Each point may or may not be convex, thus alternating convex and not convex point, enables us to encode information. Since the array of six binary symbols can take on only 64 variations, the encoding of some characters used by the control characters (similar to the escape sequences). The vast majority of blind and deaf blind people are familiar with the alphabet in Braille, so all the existing solutions for the information above is based on this alphabet. Transmission of information in our product is also based on the Braille alphabet, but Braille character encoding is not based on convex points, our alphabet is conveyed through the use of vibrations for Braille characters.

The simplest version of our proposed solution uses a common communication-feedback joystick equipped with a Vibro. This device has an output device, which uses the Braille alphabet and allows the user to input information by moving the joystick. As shown in Fig. 1, to transmit one symbol alphabet Braille using a standard joystick, six points of the symbol are transmitted simultaneously by vibration: a convex point is passed through a strong and continuous vibration. The non-convex point is passed through a weak and short vibration. The transfer is made sequentially from the top to the bottom of the first column, and then from the top to the bottom of the second column. After transmitting each symbol there will be transmitted inter-symbol pause.

The main advantage of this method of communication is its extremely low price, the cost of a controller starts from $10.

Obviously the main drawback of this approach is the low data rate making the transfer of information slower compared to a visually impaired person reading Braille. The visually impaired will take all the points of a character simultaneously and this was not possible with a controller.

To solve this problem, we've developed a special controller, which we call Vibro6, this is shown in Fig. 2 and Fig. 3. This device looks like an ordinary computer mouse, there are six vibro in three rows of two motors in series in the place where the palm of user is rests, ie, the location of the engine repeats the position of the points in the symbol alphabet Braille. Vibro is placed so that you can send Braille letters of the alphabet in parallel, which speeds up the process of transferring information from the PC to the user and allows you attain comparable data transfer speeds that provide Braille displays.

Figure 1. Serial Communications of Braille alphabet characters by using the joystick

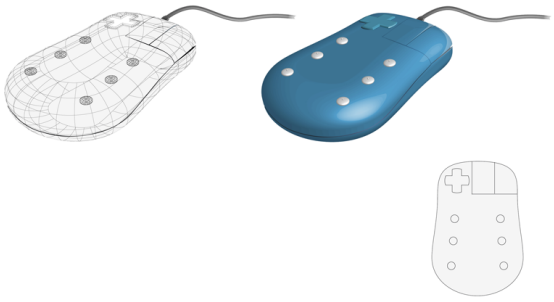

Figure 2. Project of device Vibro6

Figure 3. Vibro6 engineering sample

In addition to the output of information, Vibro6 can also be used by the user to input information. On the top of Vibro6 there is a cruciate four-way key for navigation and a button which is used for confirmation of the action. Also the controller is equipped with additional buttons (like many of today's mouse) to facilitate management of software product "Dashpoint".

Our solutions offers the following features:

-The possibility of being able to communicate with the user, using a normal joystick and a specially designed controller with a vibro attachment so that the Braille alphabet symbols are transmitted naturally and understandably

-possibility of using a mobile phone as a platform and to run the application and at the same time as a controller (currently only supported by Windows Phone 7)

-solution is an integrated environment in which for deaf/blind implemented opportunities related to training and opportunities and to communications.

IV. DASHPOINT SOFTWARE

The above-described controller Virbo6 is a support tool by which information is transmitted, the main core of "Dashpoint" is software that implements the education features, communication features and ability to expand the functionality.

Dashpoint consists of a core, which translates the symbols of the usual alphabet to the Braille alphabet and transfer of the symbols via vibrations applied to the controller. All other functions are implemented via a

separate module which we call gates. A description of the currently existing gates:

-Edu.gate implements the functionality associated with education. With this gate, deaf/blind can read literature and specially prepared training materials, and could also pass any test included in these special training materials.

-Communi.gate: allows the deaf and blind to communicate via MSN and Google Talk, enabling communication with other deaf/blind, and all other users.

-Social.gate: provides deaf/blind users with limited features while using today's popular social sites like Facebook and Twitter.

-Info.gate enables the user to receive information via popular stes like Wikipedia and RSS.

The kernel implements written by us Dashpoint API, through which the functionality of the project can be extended by third-party developers who can create new gates. However, even the existing gates at this time are enough to talk about accessibility for the deaf blind users who demand a tool for educational and communications.

Although the application is designed for use by people deprived of their sight and hearing the application has a GUI. The GUI is designed for people who can help deafblind users in the early stages of learning and how to use the application, how to pre-configure the application and monitor its correct operation in case of difficulty for the user. As with any new tool, it is inevitable to encounter problems in the early stages of use. In Fig. 4-6 shows screenshots of applications demonstrating the operation of some gates, application settings and the mobile version.

Ease of navigation depends upon the type of controller and there will be slight variations in use because of this. In the application using the Vibro6, hardware buttons are provided on the controller. Whilst still using the conventional joystick, navigation is achieved via the joystick movement and joystick buttons. Moreover, if the user's PC is equipped with touch screen or graphics tablet, the navigation is possible by means of touch on the screen/tablet. Navigation in the mobile version uses movement embedded in the Windows Phone 7 phone accelerometer and touch on the phone.

The application for the PC is written using Microsoft. NET Framework 4.0 in the language C#, GUI is implemented using WPF, xml is used to store data. The mobile application is written using Microsoft. NET Compact Framework, the application interface is implemented using Microsoft Silverlight, Microsoft SQL Server CE is used for storing data.

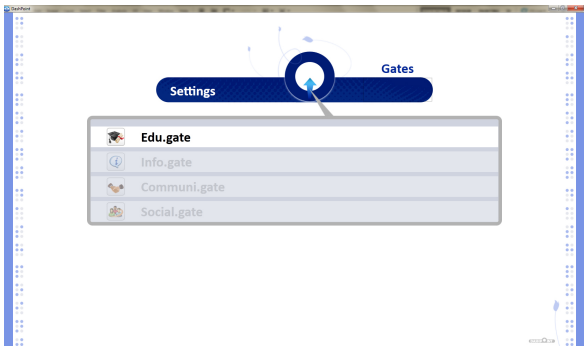

Figure 4. Dashpoint main menu screen

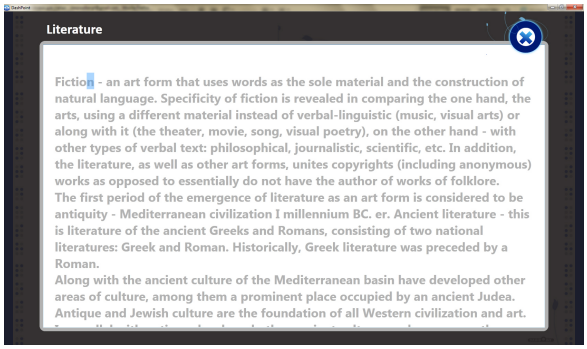

Figure 5. Reading process on PC

Figure 6. Mobile Dashpoin screenshots

Interaction with third-party developers in our project is realized on the basis of Managed Extensibility Framework. For potential developers we will provide an interface to input and output data to the device, the interface will be used to control the device and the interface will navigate within the developed module.

The interface for input and output has the following feature set: translation of a symbol to the Braille alphabet, translation of Braille symbol to vibration while receiving a user-entered character or gesture.

The interface used for controlling the device performs the following functions: a function that allows you to adjust the reading speed, a function that returns the current reading speed, a function for building a specific module setting in the program settings. Also each module has its own navigation system (menu, submenu), we provide a seamless integrated software project.

V. PLANS FOR FUTURE OF PROJECT

At the moment the project "Dashpoint" is a set of serviceable products, which includes software for the PC, software for Windows Phone 7 and controller Vibro6. We plan to continually develop the project. Over the next 6 months we plan to implement the following functions:

-support for web cameras for gesture recognition, and user input data

-server for synchronization. User is using the PC and Mobile versions they will be able to move seamlessly from one device to another while maintaining progress in learning, the history of communications in chat rooms, stories read RSS feeds, etc.

-development of game.gate, which will enable deaf blind play locally or over a network with others in chess, checkers and battleship.

-increased support of Facebook in social.gate

-expansion of the functions in social.gate and communi.gate in order to support other messaging systems and other social networks

-to develop mobile applications for other mobile platforms: Android and iPhone.

ACKNOWLEDGMENT

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REFERENCES

[1] http://www.sense.org.uk/what_is_deafblindness/urgency

[2] http://www.aadb.org/FAQ/faq_DeafBlindness.html#count

[3] http://betalabs.nokia.com/apps/nokia-braille-reader

[4] M. Rajasenathipathi, Dr. M. Atrhanari, “Conversion of English Text to Braile Code vibration signal for Visually Impaired People,” IJCSIS International Journal of Computer Science and Information Security, Vol. 8, No. 5, pp. 59–63, 2010.

Projects Modernization of the educational process in elementary and secondary schools (2009 – 2013)

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***Abstract*— Regional Education Reform in Slovakia is nationwide implemented in all schools for the third year now. The main pillars for achieving its objectives are national projects executed by the subvention of EU in operating program Education and coordinated by Ministry of Education, Science, Research and Sport of the Slovak Republic. This paper presents the objectives and activities of the projects Modernization of the educational process in elementary and secondary schools.**

***Keywords*— MVP – ZŠ the National Project of Modernization of the educational process in elementary schools, MVP – SŠ the National Project of Modernization of the educational process in secondary schools, e-educational content, teacher's training, study materials for the modern education, educational portal.**

I. INTRODUCTION

National educational projects - a bridge leading to school reform?

Educational reform in primary and secondary schools in Slovakia, across the EU and the world is a long-term process, which is an essential part of changing the world around us.

The unmistakable signs of the reform still are: technological modernization, human resources training and in particular the change of learning process; whole-area and local as well. National projects of education are currently still seen as the fundamental pillar and tool for the state to create the conditions in the real time to achieve the objectives of the reform for all participating schools in the projects.

II. OBJECTIVES OF NATIONAL PROJECTS MODERNIZATION OF THE EDUCATIONAL PROCESS IN ELEMENTARY AND SECONDARY SCHOOLS

Projects Modernization of the educational process in elementary schools (MEP in elementary) [i] and Modernization of the educational process in secondary schools (MEP in secondary) are about to innovate and modernize the content, methods and outputs of the educational process to reach new responsibilities of working in modern 21st century school- less memorizing for children, more interesting and varied lessons, better opportunities for self-fulfillment and a new system of career advancement for teachers. Another aim of these projects is to increase the number of teachers participating in the programs of continuing education to acquire and develop their competencies required for the knowledge society. Basic target group for these projects are elementary and secondary school teachers, in total of 6850 teachers. Projects are implemented between 2008 and 2013 and are co-financed by the European Union.

Executive of the project: Institute of Information and Prognoses of Education, Staré grunty 52, 842 44 Bratislava.

Supplier of educational services: elfa, s.r.o., Park Komenského 7, 040 01 Košice

Figure 1. Logos of the national projects MEP in elementary and EMP in secondary schools

Figure 2. Logos of the Operating program Education and European Social Fund

Aims of the projects EMP in elementary schools and EMP in secondary schools:

- To achieve changes in forms and methods of teaching in the schools due to the support of digital content and ICT.
- To prepare teachers for the active implementation of school reform and modernizing the education system of the further education for graduates and their preparation for life and work in a knowledgeable society.
- To provide schools with computers and other technical devices and laptops for teachers

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- To provide schools with e- educational content for the selected general courses in elementary school (Mathematics, Physics, Chemistry, Biology, Geography, History, Slovak language, Music, Art, and for the First Grade courses) and for the general courses in secondary (Mathematics, Physics, Chemistry, Biology, Geography, History, Slovak language).
- To develop methodological materials for teachers with a theoretical background for the modernization process as well as specific methodologies and examples of modern forms and methods of education using ICT.

The primary target groups are teachers:

- 4,325 teachers in elementary school from the whole of Slovakia except Bratislava district (BD) and 380 teachers in elementary school from BD
- 1,840 teachers in secondary school from all over Slovakia except Bratislava district (BD) and 305 teachers in secondary school from BD.

The secondary target group of the projects MED in elementary and secondary schools are the students of this schools, because teachers are trained to actively apply new forms and methods of education in their work with the support of digital content and ICT.

Number of participating schools and registered teachers overview:

	Existing amount		Planned amount
Elementary schools	2191	88,49 %	2476
Secondary schools	797	93,65 %	851
Teachers (elementary schools)	5172	109,93 %	4705
Teachers (secondary schools)	2344	109,28 %	2145

Figure 3. *Source: Monitoring of the projects MEP in elementary and secondary schools, September 2011*

III. PROJECTS IMPLEMENTATION

2009

- In January, the Institute of Information and Prognoses of Education (IIPE) established management team for the projects. At the same time, the building of a professional structure for the project, managed by coordinators and professional supervisors from universities and educational institutions started. In its first half public procurements by IIPE were made, the expert teams for the target groups of general education courses were formed gradually. Expert teams consist of innovative teachers from elementary schools, secondary schools and universities from the whole of Slovakia.
- March to September, teachers started to sign in for the projects. Total number of signed in teachers from elementary and secondary schools is 7,790. Expert Group selected the number of 6850 most suitable candidates for the training.
- Expert teams for the general education courses have been created (approximately 120 innovative teachers).
- The promotional and informational materials were created.
- Through the IIPE portal (www.uips.sk),the participants could electronically log in to the project and in the same time the support call center for schools, project participants and public started to work.
- There were actually two portals created and used for the project at the beginning. In terms of current requirements arising from the practice of the projects, both are regularly updated and extended by new features.

3.1. Educational portal

(www.modernizaciavzdelavania.sk) serves to enable the educational content for the participants - trainees, for the organization of education and the final CONC. The portal is destined for the project trainees, lectors, consultants and the final work reviewers, the members of examination commission, the implementer and executive of the projects. This portal won second price in the competition "E-learning in praxis", that was announced during the eight year of international conference ICETA 2011. Portal is moreover the leading "e-face" of the projects – it enables information about the projects to the general public.

3.2. Internal portal for management and administration of the projects

(www.mvp.elfa.sk) is destined for internal management needs and project administration. Range of users is therefore compared to the education portal narrowed by the people from the professional teams (coordinators, supervisors, experts, developers, lecturers and consultants), the supplier and implementer of the projects. The portal is not intended for trainees, schools, general public not excluding.

Since October 2009 to June 2011 in the portals:

- 1,251,053 a total number of visits,
- 1573 average daily number of visits
- 9,573,360 page seeing
- 1,617,196 seeing the detail of the education
- 59.66% of multiple visits within one day
- 815,722 emails sent
- 78.722 GB - of data size
- 216 dynamic websites
- 7792 registered users

Source: elfa, s.r.o.

- Throughout September-November, the schools were gradually provided with hardware equipment for special classrooms and laptops for the teachers signed in for the projects.

- May to September training centers (TC) from all over Slovakia were selected to ensure optimum availability for trainees. At the same time, basic technical infrastructure for the TC was provided and the lecturers were selected.
- In October, the teacher training began in 28 TC in Module 1, which was focused on digital literacy. In the training, each participant received a methodical material and the exercises for praxis available on the portal as well.
- The teachers' education is integrated system of three Modules in the range of 100 hours for advanced to 106 hours for intermediate (related to a module – the same starting point for all trainees in the projects - digital literacy, a necessary requirement for many experienced teachers). Education runs in presence and in distance form, ends by creating thesis and the final examination. This teachers educating is accepted in the new system of teacher career.

In the final quarter of 2009, working on the additional methodical materials for Module 2 and Module 3 continued.

Figure 5. Educational portal: www.modernizaciavzdelavania.sk

2010

- In 2010, methodical textbooks for teachers for Module 2 and the common part for Module 3 as well as for the 17 selected subjects in elementary and secondary schools were issued. In these, the experimental digital content using ICT is verified. Overall, since the projects started, number of 20 methodical textbooks for teachers – each graduated trainee gets the textbook for Module 1, Module 2, and the common textbook for Module 3 and textbook aimed for the subject in which they received education were created and issued.
- At the same time, there is a digital library on the educational portal of the project, where there is the experimental digital content for every selected subject for trainees available.
- In February, all trainees completed Module 1.
- Since April, in 20 TC teachers educating in Module 2 "The modern didactic technique in teachers work" was launched. Module 3 preparation continues.
- In the summer, teachers started educating in Module 3 "Using the ICT in the subject".
- In 2010, first 40% of trainees in Modules 2 and 3 were educated.

2011

- In March, the first final exam started.
- Educating process of the teachers is completed by creating the final thesis and its defense and a final examination in which they have opportunity to present their readiness to implement modernization elements to the educational process in elementary or secondary school. Teachers demonstrate adequate knowledge of ICT applications in teaching of their subjects with focus on the implementation of a national education program in elementary or secondary school. Teachers, who successfully completed the educational process of the projects, completed specialized training in law no. 317/2009 body of law: The teaching staff and professional staff are then granted 35 credits. The programs "Modernizing the education in elementary schools with ICT" and "Modernizing the education in secondary schools with ICT" are accredited continuing education programs (specifically as specialized training) in law no. 317/2009 body of law: The teaching staff and professional staff.
- Until May, 3,693 training days were completed by trainees.
- 13, 5% of all trainees (signed in teachers) calls for specific changes in the project. To move days of education, or to move the date of the final thesis defense and tests. This is because of the different life situations (change of employment, dismissal, cancelled schools, maternity or parental leave etc.).

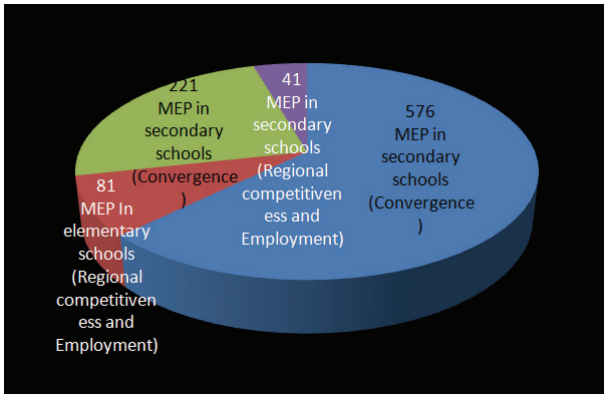

Figure 6. Source: Monitoring of the projects MEP in elementary and secondary schools, September 2011

Expert team: The nature of the project

Creative work of expert teams throughout the year is focused on detailed analysis of the current state in the range of modernization of education, i.e. new trends in ICT in primary and secondary school subjects and

analyzing and preparing the digital content for the education process. Innovative work of experts lines in the preparation of model guidelines for the modernization of education using ICT. The main directions of modernization are not set on technology but on the teaching process, changing the education atmosphere, increasing the activity of students and their own responsibility for their learning as well as the new competencies for the teacher in the process of modernization of education. Teachers' final thesis must be oriented on the new forms and methods of work in a modern school where ICT plays the only necessary role to achieve the aim of school transformation from traditional to modern – a 21st century school.

IV. Conclusion

Total number of 85% Slovak elementary and secondary schools are involved in the national projects Modernization of the educational process in elementary and secondary schools. This means that almost all schools involved in the project were provided by computers destined for multimedia computer classrooms (for supporting the implementation of the project MEP results in practice) and laptops for lecturers and trainees - the teachers who participated in the project and began to meet the objectives of project MEP by beginning to learn on the digital basis. Through this step they can get inspired by digital technologies that are available on the internet and free of charge, as well as the paid for software, to make their never-ending journey to the modern way of teaching easier, along with the continual self-education and updating the content of the curriculum / learning, which should reflect current and future needs of the primary target group of regional schools, as well as the projects MEP in elementary and secondary schools - students, as well as globally – the whole world.

Range (85% of elementary and secondary schools from Slovakia) and duration (2008-2013) of national projects Modernization of the educational process in elementary and secondary schools (for the exact classification of projects by the bureaucratic structures see endnote [ii]) are like 'quantitative' predestinating, that that in addition to implementation (in later stages) and after successful finishing of the projects (filled with measurable indicators - in this case the number of participating schools and successful teachers - graduates of the projects MEP) will be satisfied the basic purpose of the projects: to prepare teachers for the active adapting of education system for the needs of knowledgeable society. That is executed as a part of the active implementation of school reform. The key to its fulfillment is considered to be teacher - with new competencies for education in the modern school.

V. Additional Information

Current situation in the national projects Modernization of the educational process in elementary and secondary schools can be monitored at http://www.modernizaciavzdelavania.sk .

[i] Ministry of Education, Science, Research and Sport of the Slovak Republic with support from EU Structural Funds and national budget as well declared national projects for years 2008-2013:
Call OPV/K/RKZ/NP/2008-3 Modernization of the educational process in elementary schools
Of purpose: Convergence (whole Slovakia, except Bratislava district), project code: 26110130083
Of purpose: Regional competitiveness and Employment (Bratislava district), project code: 26140130013
Call OPV/K/RKZ /NP/2008-4 Modernization of the educational process in secondary schools
Of purpose: Convergence (whole Slovakia, except Bratislava district), project code: 26110130084
Of purpose: Regional competitiveness and Employment (Bratislava district), project code: 26140130014.

[ii] Classification of MEP projects: „Modernization of the educational process in elementary schools"(ITMS: 26110130083, 26140130013) and „Modernization of the educational process in secondary schools"(ITMS: 26110130084, 26140130014) – separately for Bratislava district (of purpose Regional competitiveness and Employment) and separately for the left whole Slovakia (of purpose Convergence), two mirror projects.

Acknowledgment

We thank our colleagues who help us to realize objectives of the national projects Modernization of the educational process and especially teachers who are interested to work on their personal development and signed in in to this project.

References

[1] http://www.modernizaciavzdelavania.sk
[2] http://www.uips.sk
[3] http://www.minedu.gov.sk

Realization of subjective tests in the environment of streaming services

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***Abstract*—Increasing requirements on video quality seem to be essential while designing any video-oriented services. The methods in the user-centered design of services are fairly labor intensive and have to consider resulting value of user experience. However, user experience is a term that is currently very hard to be defined. There are different approaches to user experience assessment, which lack an ultimate method to predict expected user experience. In this article, we introduce a system that enables web service providers to measure quality of service provided to end-users while playing online video content that is approached via http progressive streaming. This tool is also suitable for future educational purposes in the field of video quality evaluation.**

I. Introduction

Nowadays, media streaming has become one of the most used network service oriented on multimedia. In the world of telecommunication service providers we see upward trend in providing of combined voice, video and data services. Video can be considered as a new feature in this scheme but it importantly change the whole aspect of the way how we work, live, learn and how we communicate between each other. Few years back YouTube was only a web-page where you went to entertain yourself while watching music videos. Nowdays we can consider YouTube as the second biggest search engine after Google and before Yahoo, which just underline the fact that video is potentially becoming the future source of information not just an instrument for entertainment. With the importance of user's mobility the corresponding multimedia services need to be highly reliable to earn the trust of it's customers. This is why we need precise assessment methods and frameworks to guarantee a specific level of user experience. In order to archive this goal we firstly need to consider which parameters have influence on degradation of user experience and quality of multimedia content. This has been done with signal-to-noise ration (SNR), peak signal-to-noise ration(PSNR) or bit error rate (BER). However, the latest measurements shown that they do not correlate well with quality perceived by an end-user [1]. Therefore, concepts such as Quality of Service(QoS) and Quality of Experience (QoE)[2][3] has been introduced. But most of the current approaches are oriented to one specific video content type/application or to one scenario which is not enough. Video quality metrics need to be more complex and cross-content to provide better correlation with subjective ratings that are really important for appropriate decisions on a suitable optimization method for video streaming.

In this paper we present a video quality measurement tool, a concept that is based on a real-time statistical data gathered at the client-side, which are lately send to a remote database. In order to explain the functionality of the measuring tool, we will firstly introduce the streaming technology that the tool is built on. Next, we will discuss the quality of video in context of http streaming, followed by identification of the factors that influence the resulted quality of service. These factors are key-components of our client-side video measuring tool. At last, we will analyze tool's functional topology and components it is composed of, with brief description of technologies and implementation process of the tool.

II. Foundation

In the following, we outline the main terms needed to understand the problematic of this paper.

User Experience: we can understand it as an experience that an user achieve during the process of interaction with a product or service. However, we have to have in mind that user experience is highly influenced by different factors like user expectations, experiences or state of mind.

A. Assessment of User Experience

There are several approaches that are used to measure video quality and corresponding user experience.

a) Subjective Quality Assessment:: the quality of perception is not a term that is exactly defined or can be easily computed. It is cause of fact that it is connected at most of the time with particular viewer. This viewer then can define the quality by his own scale and internal judgment. Therefore, the result is most of the time influenced not just by the quality of perceived video sequence, but also by specific state of mind of particular viewer. There are several standards that orient on subjective quality assessment of video and audio quality. They can be found in ITU-R Rec. BT.500-11[13] and ITU-T Rec. P.910[4].

b) Objective Quality Assessment:: on the other hand compared to the subjective quality assessment, objective quality assessment is a technique that is most of the time defined as a mathematical model for estimating of the subjective quality assessment. It builds on metrics that can be automatically evaluated by a computer. These metrics then are divided into three groups on account of availability of a reference video.

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- *Full-reference (FR) metric*: is a technique where we fully use reference video to compare its quality to test video. The whole process is done in two steps, the first step calculates the errors between original and distorted images and the second one has to pool the particular errors to a global quality assessment[14].
- *No-reference (NR) metric*: here we analyze only test video without the need to compare it with the reference video. However, this technique uses some prior information, like type of encoding to be able to look on codec-specifications.
- *Reduced-reference (RR) metric*: is a hybrid between FR and NR metric in terms of the reference information. This approach is suitable mainly cause of managing of the amount of reference information we use.

B. Mean Opinion Score (MOS)

We can defined *Quality of Experience* (QoE) as a number in range between 1 and 5 used to express level of quality in multimedia (audio, VoIP or video)[Tab. I]. MOS for voice is standardized in ITU-T R. P.800[15]. The value of MOS is acquired by subjective assessment tests, where the attendants rate the audio or video quality of the test sequence.

TABLE I
LEVEL OF QUALITY IN MOS

MOS	Quality	Impairment
5	Excellent	Imperceptible
4	Good	Perceptible, but not annoying
3	Fair	Slightly annoying
2	Poor	Annoying
1	Bad	Very annoying

C. Parameters influencing QoE

Another important factors that we need to consider are the values of video parameters like bit rate, video resolution, frame rate and codec, or network parameters like bandwidth, delay, jitter and packet loss. *Bit rate* represents the number of bits processed during one time unit. *Video resolution* is a size of video image an is measured in pixels, where the numbers represent horizontal and vertical resolution. *Frame rate* specify a frequency at which the streaming device produce images that are called frames. *Bandwidth* is defined as the amount of data per one time unit that are delivered over physical network topology, from the source to the destination. *Jitter* is best represented as an end to end delay between one packet to the next, within the same stream. *Packet loss* defines percentage of lost packets. *Delay* represent lapse of time or amount of time during some action is awaited. *Video codec* is a software used for encoding and decoding of a digital data stream.

III. STREAMING CONCEPTS

There are two major approaches how to stream video over the network. First approach uses standard Web server, e.g. Apache Http Server Project, and uses standard hypertext transfer protocol HTTP to deliver video and audio data to the client. The second approach uses separate streaming media server, e.g. Wowza Media Server. Both methods bypass old-fashioned download-and-play technology, where you have to download the whole file before playing it. Nowadays, there is a big demand on high quality for media content on the Internet. This new streaming technologies had to be designed to provide both quality and transfer time to satisfy Internet end-user.

A. Streaming with a Web Server

This approach is only a small evolutionary step from download-and-play model. Uncompressed audio and video are merged together to a single media file and then placed on standard Web server hard disk to be available for delivery on specific bandwidth. Next, a web page containing URL to this media file is placed on the same Web server. When request to this web page from a client is sent to the server, it launches client-side media player embedded in a web browser and a download of the media file to the client using http protocol will start. This can be achieved also by using media player and specify URL to the file to start this process. Application layer protocol http (in TCP/IP network model) on client-side will generate http request. Web server after receiving this request will start sending requested file with TCP protocol in context of http response. Unlike download-and-play model, client-side media player starts playing media file while the file is being downloaded. This is also called a progressive download. Only certain media file formats support this type of download. As we discussed earlier, this type of streaming uses http protocol that operates on top of the TCP. TCP retransmits lost packets and cannot assure that all resent packets will arrive at the client in time to be played in the media stream.

B. Streaming with a Streaming Media Server

This type of streaming is the true streaming. It uses dedicated streaming server to deliver data to client-side media player. This allows real-time broadcasting of live events and ability to control playback. To run own streaming server, there is a need to have licence of it. Some examples of such servers are Flash Media Server, Wowza Media Server, Windows Media Server, Darwin Media Server (QuickTime) and Real Media Server. Streaming servers can use variety of streaming protocols such as RTMP, RTSP and MMS that can handle transfer, communication between client and server.

IV. QUALITY OF VIDEO IN CONTEXT OF HTTP STREAMING

Because video data are transmitted over a communication network, the size of digital video data is an important issue in multimedia technology. Consequently, this data must be compressed before transmission in order to optimise the required bandwidth for the provision of a multimedia service. In a context of the http streaming technology, we focus on two main factors - video quality and bandwidth. It is necessary to tradeoff the network capacity against the perceptual video quality in order to come up with the optimal performance

of a video service and an optimal use of underlying network infrastructure. Moreover, coded video streams are transmitted over network and thus exposed to channel errors and information loss. In this article, we introduce a tool that would help find this optimal performance for video service built on http streaming architecture.

A. Video quality

In terms of video quality, the parameters that we must consider are attributes like bit rate and video codec, video resolution and frame rate. Bit rate represents the number of bits processed during one time unit. Video resolution is a size of a video image measured in pixels, where the numbers represent horizontal and vertical resolution. Frame rate specify a frequency at which the streaming device produce images that are called frames. Video codec is software used for encoding and decoding of a digital data stream.

B. Bandwidth

Digitally compressed video is transferred over a packet-switched network. The physical transport can take place over a wire or wireless, where some transfer protocols like ATM or IP ensures the transport of the bitstream. The bitstream is transported in packets whose headers contain sequencing and timing information.

C. Network topology

It's obvious that each client can use different connection to the network and generally, video streaming is provided across Internet platform, thus every client will experience different bandwidth connection to the HTTP Server. HTTP streaming uses TCP unicast packets to each client. Our tool is constructed to monitor traffic and video parameters on each client thus providing a complex view what is the quality of service to the clients.

V. Introducing the Tool

This part of the work introduces design and implementation of the tool used to perform subjective assessment of video and audio quality based on gathering statistical data from respective measurements [Fig. 1]. It is the system that makes possible to assess video quality and streaming service as a whole on given architecture. The tool uses true streaming for delivering data with protocols as RTP and UDP and also video-on-demand principle with HTTP protocol. The tool is built on a variety of modern and powerful programming languages (C/C++, AJAX, Javascript, PHP, SQL), open-source and reliable applications (VLC Videolan Project, MySQL Server, Apache Server) and implemented with effective and high-performance standards and methods (multicast, RTP protocol). The tool represents an advantageous solution for gathering different client-side statistical data and subjective assessment data. This data are sent to remote database server and processed as needed. The combination of subjective and objective data makes possible to better analyze subject's assessment and to detect problems.

Fig. 1. Web interface of the presented system

A. Functional topology and components

The system consists of several components - http server, web page located on the server with specific client-side scripting code, media plug-in in clients' web browsers and database server. Http server provides web page with link to the video to be streamed. Web page contains specific functions that exploit functionality of media plug-in. Media player plug-in is primarily used to playback streamed video on client side. Player is embedded in a web browser and processes the video that is being downloaded. Media player plug-in has been modified to provide needed functionality - to provide real-time video statistical data such as input bitrate, read packets, state of playback, frames per second, etc. Web page contains code written in client-side web scripting language, so it runs on client side and handles the data gained from media plug-in. The gathered data can be sent to remote database where they are stored and third-party applications could access this data and evaluate them. The functional topology is shown in the [Fig. 2].

B. Adequate Parameter Choice

The tool monitors many parameters at client-side that help to find out the circumstances during assessment process and also depict characteristics of user playback. These parameters can be divided into four groups (Input, Video, Audio, and User parameters). The choice of these parameters must by adequate in order to carry objective information about circumstances and characteristics of user video sequence playback. Input parameters characterize the processing of incoming media stream (total read packets, read bytes, input bit rate, read packets rate, read bytes rate, corrupted blocks in demuxer, time of playing). Video parameters characterize the processing of video data (displayed pictures, lost pictures, resolution, frames per second). Audio parameters characterize the processing of audio data (decoded audio blocks, lost audio blocks) and finally user parameters characterize software and hardware of user (total memory, available memory, cpu frequency, operating system, browser, estimated connection speed.

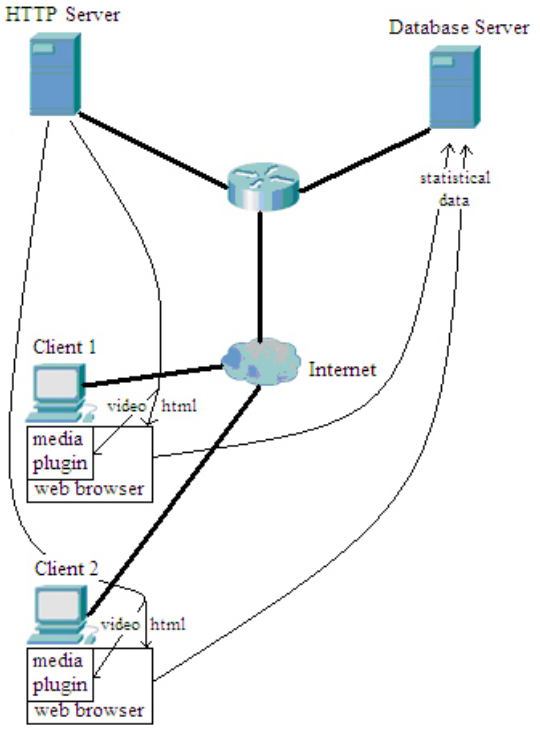

Fig. 2. Functional topology

C. Obtaining Media Sequence Information

The system stores characteristics for every multimedia sequence used for testing purposes. Sooner as the sequence is subject to assessment, it must be registered in the system and some information about it must be obtained. This information is automatically gathered using cgi script after the sequence has been successfully uploaded to the content server. The information includes general information about multimedia file (format, file size, overall bit rate, duration, bit rate mode, etc.), general information about video streams (format, bit rate, width, height, display aspect ratio, frame rate, standard, color space, chroma subsampling, bit depth, scan type, compression mode, etc.), general information about audio streams (format, bit rate, channels, sampling rate, bit depth, compression mode, duration, etc.) and general information about text streams (format, video delay, etc.). This information is valuable to identify sequences' needs to streaming service, structure and restrictions. Obtaining and storing of this information is integrated to the system what increases simplicity and flexibility.

D. Realization of Subjective Assessment

1) *Creation of data stream* - in the case of true streaming administrator starts for given sequence multicast streaming to network with protocol RTP or UDP. In the case of video-on-demand, for every request from user the separate unicast HTTP data stream is produced.
2) *Creation of playback instance* - user requests data stream (multicast or unicast) using web browser multimedia plug-in.
3) *Creation of user profile* - for every playback instance a new user profile is created - information about user hardware and software and estimated connection speed is obtained.
4) *Gathering real-time statistical data during playback* - gathering data in the background about incoming played stream.
5) *Multimedia sequence assessment* - - user can at any time assess played sequence. Three aspects are assessed - video quality, audio quality and playback quality, using five grade numeric rating scale (1 - Excellent, 2 - Good, 3 - Fair, 4 - Poor, and 5 - Bad).
6) *Sending data to database server* - when all three aspects are rated, the data are automatically sent to remote database using AJAX technology.
7) *Analysis of gathered data* - data is gathered in logical hierarchy and interpretation of results is left to administrator.

E. Implementation of gathering client-side statistical data

Gathering statistical data is performed by web browser and Javascript. This concept is used for its simplicity, it is not practical to ballast user with installation and maintaining of other applications. Data represents input data for local application embedded into web browser. The question is, how can one get access to this data in web browser using Javascript. Normally, it is restricted to access computer local data because of security. But the tool exploits embedded plug-in (VLC Multimedia Plug-in) to get access. This extended functionality has been simply added because VLC Multimedia Plug-in is open source and can be modified as needed. To access data, the tool calls Javascript API of the plug-in. This concept is really transparent, simple and powerful. Extended functionality represents creation of new Javascript object - Stats and Client besides others. The example of using these objects in web page is as shown below.

```
< scriptlanguage = "Javascript" >
var vlc = document.getElementById("vlc");
var readBytes = vlc.stats.readBytes;
var readPackets = vlc.stats.readPackets;
var inputBitrate = vlc.stats.inputBitrate * 8000
var displayedPictures =
vlc.stats.displayedPictures;
var lostPictures = vlc.stats.lostPictures;
var decodedVideo = vlc.stats.decodedVideo;
var decodedAudio = vlc.stats.decodedAudio;
var totalRAM = vlc.client.totalRAM;
var availRAM = vlc.client.availRAM;
var cpuSpeed = vlc.client.cpuSpeed;
< /script >
```

VI. Related Work

A number of studies have explored the idea of predicting user experience. The most interesting approaches combine the objective measurements with the empirical experiments

gaining subjective ratings such as the MOS [4] to get user experience estimation. There is a lack of approaches that build a prediction models on this basis. Some, like [5] and [6], correlate measurements on both the sender and receiver sides. Others, like [7] and [8], use the Emodel [9], an objective mechanism for assessing audio quality using transmission parameters. An alternate approach is to utilize application-layer objective metrics, taken at the clients machine through an instrumented media player application [8], [10], [11], [12]. These approaches allow one to take measurements without requiring the users participation, providing a more accurate assessment of the user experience, but do not provide prediction models.

VII. Conclusion

Presented approach is based on the analysis of user experience sensitivity on a changes of videostreaming quality attributes. Using this tool, service providers take advantage of high performance tool to gather real-time client-side streaming video statistical data. Data are retrieved and processed at client side, so the streaming server is not unnecessary stressed. This data can be consequently sent to remote database where they are stored and linked to particular client. Third-party applications can access this data and evaluate them. This helps to identify and solve problems with streaming service and improve quality of service. Presented tool is built on open source software, which is flexible, scalable and still improving. In future, it can be used for testing and further educational purposes.

VIII. Acknowledgement

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References

[1] S. Winkler, Digital Video Quality - Vision Models and Metrics. John Wiley & Sons, 2005.

[2] D. Soldani, M.Li and R. Cuny (Ed.), QoS and QoE Management in UMTS Cellular Systems. John Wiley & Sons, 2006.

[3] F. Pereira, "Sensations, perceptions and emotions towards quality of experience evaluation for consumer electronics video adaptations," in Proc. of Int. Workshop on Video Processing and Quality Metrics for Consumer Electronics, Jan. 2005.

[4] P.910, I.T.R.: Subjective video quality assessment methods for multimedia applications. Recommendations of the ITU, Telecommunications Sector

[5] Wolf, S., Pinson, M.H.: Spatial-temporal distortion metrics for in-service quality monitoring of any digital video system. In: Proceedings of SPIE International Symposium on Voice, Video, and Data Communications, Boston, MA (September 1999)

[6] Ashmawi, W., Guerin, R., Wolf, S., Pinson, M.H.: On the impact of policing and rate guarantees in Diff-Serv networks: A video streaming application perspective. In: Proceedings of SIGCOMM 2001, San Diego, CA (August 2001)

[7] Clark, A.D.: Modeling the effects of burst packet loss and recency on subjective voice quality. In: Proceedings of the IP Telephony Workshop, New York (March 2001)

[8] Calyam, P., Mandrawa, W., Sridharan, M., Khan, A., Schopis, P.: H.323 Beacon: An H.323 application related end-to-end performance troubleshooting tool. In: Proceedings of NeTS 2004, Portland, OR (October 2004)

[9] G.107, I.T.R.: The Emodel, a computational model for use in transmission planning. Recommendations of the ITU, Telecommunications Sector (1998)

[10] Wang, Y., Claypool, M., Zuo, Z.: An empirical study of RealVideo performance across the Internet. In: Proceedings of IMW 2001, San Francisco, CA (November 2001)

[11] Loguinov, D., Radha, H.: Measurement study of low-bitrate Internet video streaming. In: Proceedings of IMW 2001, San Francisco, CA (November 2001)

[12] Nichols, J., Claypool, M., Kinicki, R., Li, M.: Measurement of the congestion responsiveness ofWindows streaming media. In: Proceedings of NOSSDAV,Kinsdale, Ireland (June 2004)

[13] ITU-R Recommendation BT.500-11: Methodology for the subjective assessment of the quality of television pictures, International Telecommunication Union, Geneva, Switzerland, 2002.

[14] M. Carnec, P. Le Callet, D. Barba, "Full reference and reduced reference metrics for image quality assessment," Signal Processing and Its Application, 2003.

[15] ITU-T P.800: Methods for Subjective Determination of Transmission Quality,International Telecommunication Union, Geneva, Switzerland, 1996

Evaluation of Erlang Models in IP Network

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***Abstract*—Our paper deals with utilization and examination of Erlang traffic theory in asynchronous networks based on IP technology. We have proposed test network model with video traffic source. The obtained results have been compared with calculations performed in Matlab environment. We have aimed to loss parameter in our comparisons.**

I. INTRODUCTION

The IP networks were not designed for providing multimedia services at the beginning. These networks were intended for data transfer without predefined paths, so that in case of breakdown of one of the routers, other path could be chosen [1]. Path of packet can change and so can change transfer parameters.

If we want to use IP networks for voice, video and multimedia transmission, we have to define transfer parameters. These parameters are covered under QoS (*Quality of Service*). For observance of QoS [2]-[5] parameters it is necessary to estimate network performance under load and link overflow.

This problem is handled by theory of queuing systems described in detail in [6]-[9]. Therefore we will try to use Erlang models well known from synchronous telecommunication networks. Erlang B model deals with data loss in relation with network load. Erlang C model defines probability of waiting of data in the waiting queue and so resembles to IP network behavior, where data queuing occurs before sending further.

II. PROPOSED MODEL

The proposed model is based on Linux open-source operating system. In this system every part of the core is documented and available [10]-[13]. Thanks to this attribute, OS Linux or its core is implemented in many devices (routers). In our case we used linux distribution Debian 4.0, installed it on a PC that serves as a router, web server, file server and other applications server. There will also be installed a simulation program for traffic simulation, that will send video flows of defined parameters. Linux is capable of packet modification from its core and we will use this feature. Labeled packets of video flow then will be concentrated into one link or divided. We will install a custom package for traffic engineering, where classes, queues and filters can be created. These three main elements are defining routing mechanisms in router. This type of server with OS linux installed can be a low price alternative to routers used in commercial networks.

A. IP Tables

IP tables is a mechanism implemented directly into core of Linux operating system and serves for setting of IP traffic rules. It can change headers or drop packets. In our case, it will be used only for packet labeling. Labeled packets can be separated into individual data flows and then formed by traffic engineering package. IP tables consist of three parts: incoming, outgoing and forwarding. We can insert rules into these groups. If packets passes first rule, other rules in chain are not tested and packet is processed with the first rule definitions. For example, it can be labeled or dropped.

B. Classes

Classes serve for keeping our defined bandwidths. If we want to reduce speed to 2Mbit/s, we can create a class that ensure, that overflowed data will go to a queue and then will be sent. Linux uses two common classes:

- CBQ (*Classfull Based Queuing*).
- HTB (*Hierarchy Token Bucket*) [14].

C. Queues

Queues in traffic engineering influence which data will be send and which will have to wait in queue. There exist many mechanisms for queue managing and they are assigned to CBQ or HTB. Queues are class independent. Basic configuration of *Traffic control* package includes following types of queues:

- FIFO (*First in First Out*).
- PFIFO *(Priority* FIFO).
- SFQ (*Stochastic Fairness Queuing*).
- RED (*Random Early Detection*).

D. Filters

Last and very important part of our flow regulation package are filters. Filter serves for inserting data into the right class. In our case, filter chooses class by labels that were added by *IP tables*. But also these filters can analyze packet headers and assign data to right classes. These filters are paired with main classes and classes then insert data correctly based on corresponding filters.

E. Proposed Network Model

Our designed model of simulation environment is shown in Figure 1. We used one client for creation of video traffic and two clients for receiving and video data processing. Whole communication ran through server, which stood as a router and traffic shaper. This network was built and configured based on knowledge from literature [14]-[18]. All network elements were capable of 1GBit/s (if we did not use server for link limitation, we would not be able to correctly measure IP network behavior under load).

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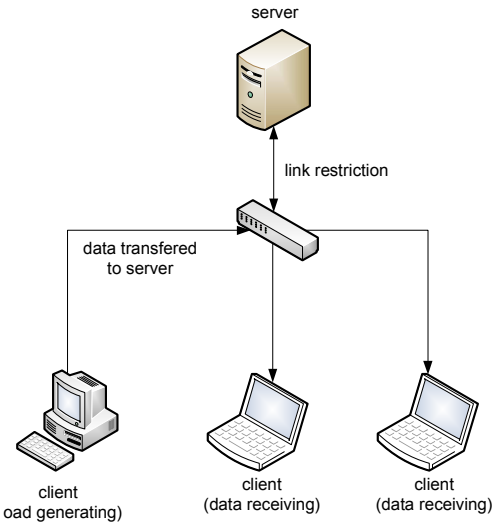

Figure 1. Proposed network model.

F. VBR Video Source

For real traffic simulation in IP network, simple model with JPG frame compression is sufficient for our purposes. As video source was used a webcam. It captured one minute long recording, all measurements used same data and so results were comparable. Our model is shown in Figure 2. and was designed based on information from [19]-[21].

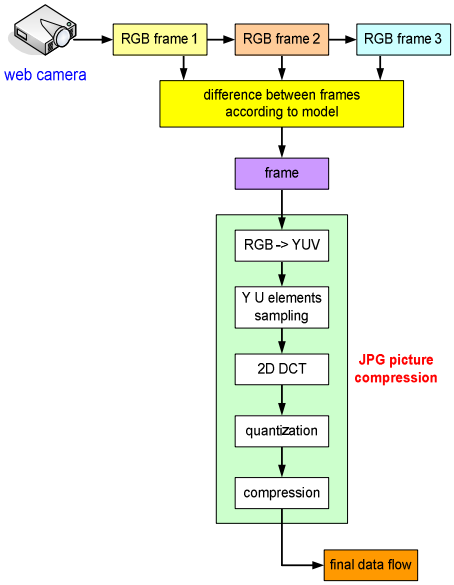

Figure 2. Video model with VBR data flow.

III. Erlang Models in Matlab

In 1917 Agner Kralup Erlang published *Solution of some Probléme in The Theory of Probabilities of Signifiance in Automatic Telephone Exchanges*. In this publication he stated his models for loss and waiting time in telephony traffic.

A. Erlang B Model

Erlang B model deals with probability of data loss under link load. Its basic form is (2):

$$B = E_{1,C}(\rho) = \frac{e^{-\rho} * \frac{\rho^C}{C!}}{\sum_{x=0}^{C} e^{-\rho} * \frac{\rho^x}{x!}} = \frac{\rho * E_{1,C-1}(\rho)}{C + \rho * E_{1,C-1}(\rho)} \quad (2)$$

where:

- ρ - total load [%],
- C - number of links.

We revised model (2) into form (3), which is more appropriate for calculations. From this model results relation of two parameters:

- ρ - link load in [%],
- C - link speed in Mbit/s.

$$E1 = \frac{\frac{\rho^C}{C!}}{\sum_{k=0}^{C} \frac{\rho^k}{k!}} \quad (3)$$

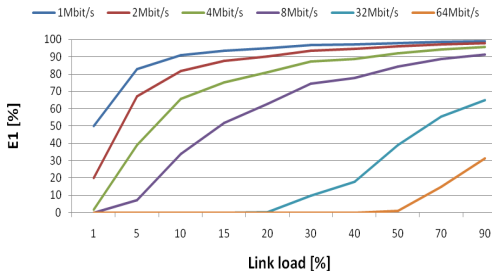

Figure 3. Data loss probability in the case of constant bandwidth.

From Fig. 3 we can see following results:

- Probability of loss increases with link load.
- With increasing bandwidth data loss is decreasing.

After revision and modification of Erlang model with parameter *m*, (number of sources in common path) we used model (4) for further calculations. Other parameters stayed the same.

$$E_1(\rho, c, m) = \frac{\frac{(m.\rho)^c}{c!}}{\sum_{i=0}^{c} \frac{(m.\rho)^i}{i!}} \quad (4)$$

Common path means that more flows are transferred through one way. Link bandwidth requirements are then summarized together.

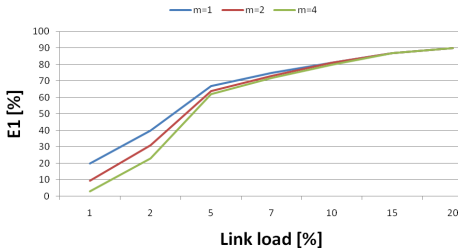

Figure 4. Data loss probability in the case of constant bandwidth 2 Mbit/s and m flows.

From Fig. 4 we can see following results:

- Under low link load with increasing number of sources is data loss probability reduced.
- Under higher link load (5%) this difference is not as much notable and the loss is gradually flatten.

B. *Erlang C Model*

Probability of waiting the requests in queue is described by second Erlang model (5).

$$E_{2,C}(\rho) = \frac{\frac{\rho^{C}}{C!} * \frac{C}{C-\rho}}{\sum_{x=0}^{C-1} \frac{\rho^{x}}{x!} + \frac{\rho^{C}}{C!} * \frac{C}{C-\rho}} \quad (5)$$

For calculations form without factorials is preferable. In case that $\rho < C$, we can rewrite model to (6):

$$E_{2,C} = E_{1,C} * \frac{C}{C - \rho[1 - E_{1,C}(\rho)]} \quad (6)$$

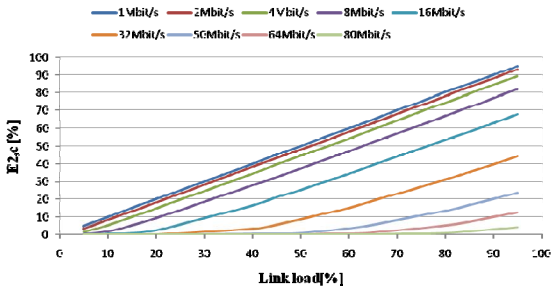

Figure 5. Probability of enqueue in case of constant bandwidth.

From Fig. 5 we can see following results:

- With increasing link load, probability of enqueue also increases.
- With increasing bandwidth, probability of enqueue decreases.
- With low link speeds (under 16 Mbit/s), the behaviour of probabilities is nearly linear.

Model (6) extended by *m* parameter:

$$E_{2,C}(m*\rho) = \frac{\frac{(m*\rho)^{Ccp}}{Ccp!} * \frac{Ccp}{Ccp-(m*\rho)}}{\sum_{x=0}^{Ccp-1} \frac{(m*\rho)^{x}}{x!} + \frac{(m*\rho)^{Ccp}}{Ccp!} * \frac{Ccp}{Ccp-(m*\rho)}} \quad (7)$$

where:

- ρ - link load [%].
- C_{cp} – link speed (for common path) in Mbit/s.
- m – number of sources.

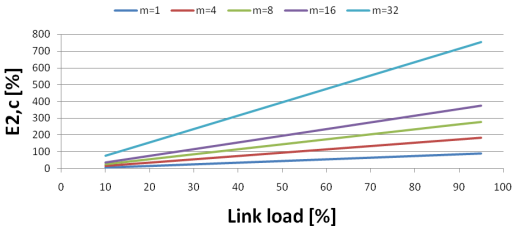

Figure 6. Probability of enqueue in case of common utilization of 4 Mbit/s link.

From Fig. 6 we can see following results:

- With increasing link load and constant bandwidth, the probability of enqueue increases.
- With higher common path utilization, the probability of enqueue is also higher.
- With increasing of common path bandwidth, it is possible multiple use of traffic links also with higher load.
- Common path bandwidth affects slope of probability of enqueue.

IV. Discussion of Results

When comparing results from MATLAB simulations and real measurements, it is necessary to consider VBR video characteristics and used queues for traffic shaping. For simulation of model B we used RED mechanism, because packets were dropped after reaching maximum queue length. Model C uses SFQ mechanism, which does not drop packets, but inserts them into waiting queue.

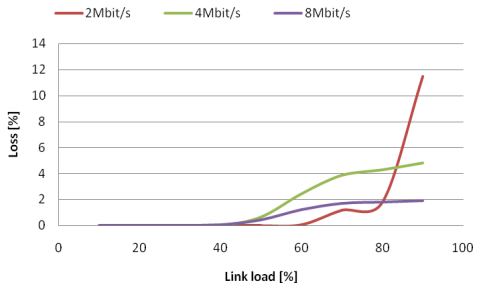

Figure 7. Loss probability in case of constant bandwidth.

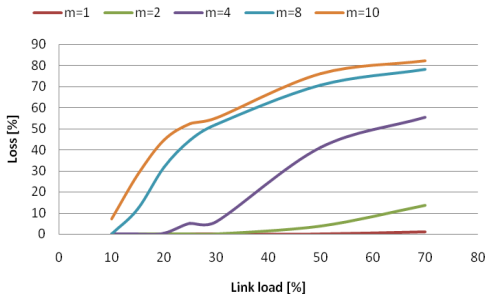

Figure 8. Loss probability in case of 2 Mbit/s link and *m* flows.

A. *Erlang B Model*

Firstly we measured loss in relation to link load at 2 Mbit/s link capacity. In Figure 7 we can see that graphs look like in simulations (section III.A), but values of loss are much lower (loss decreases with link capacity). This is caused by VBR video characteristics, where loss does not occurs until reaching link capacity.

The figure 8 shows Erlang B model with common link. Each flow was transferred with some time delay against other flows. This way we prevented overloading of the link by VBR video. From this measurement results:

- With constant network load and increasing bandwidth it is possible to raise the number of sources.
- With constant load and bandwidth, loss increases with number of sources per link.
- With increasing link capacity we can add number of sources per one path.

B. *Erlang C Model*

The method was the same as with Erlang B model, except for the fact, that data which came later, were labeled as lost, because they went to waiting queue.

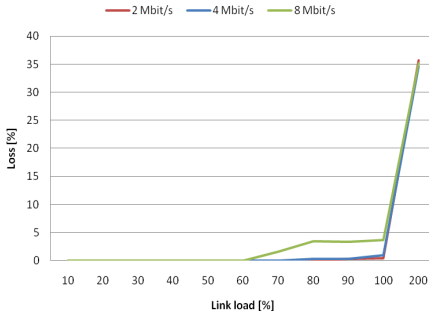

Figure 9. Loss probability in case of constant bandwidth.

From Fig. 9 we can see following results:

- SFQ waiting queue is a better choice for VBR video, because of its better handle with high-peak rate.
- Compared to MATLAB simulations, loss is under 5% even until full network usage. This is caused by SFQ queue and VBR data model.

We also tried the common path utilization with Erlang C model. Flows were put together in the same way as with Erlang B model. The results are depicted in the Fig. 10:

- Graphs are now comparable with MATLAB simulations, but with lower probability of loss.
- Similar to Erlang B model, it is useful to put together more flows into one path.
- With increasing bandwidth, we can put together more flows into one path and assure acceptable loss (based on SLA).

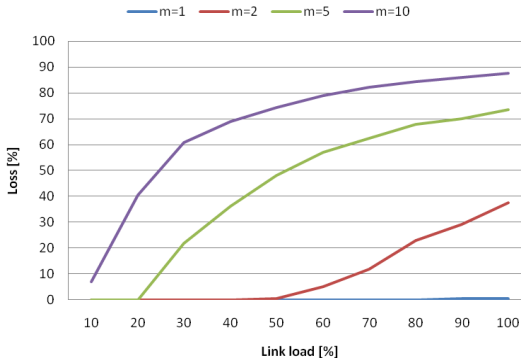

Figure 10. Loss probability in case of *m* flows and 2 Mbit/s link.

V. CONCLUSION

The purpose of our work was to evaluate utilization of Erlang B and C models in IP networks with VBR video traffic source. We have pointed out the difference between two link shaping methods and we have found out that SFQ is more suitable for this utilization. Erlang model is then a good choice for VBR traffic calculations with respect to losses. It is possible to estimate network behavior under load with these models. These models give us only approximately estimation. Loss probabilities were not exactly as predicted by calculations, but lower. It is caused by VBR video characteristics and data transfer method in IP networks. Calculations and real measurements have shown advantages of effective link load. Putting more VBR flows together into one link has greatly improved effectiveness of data transfer.

ACKNOWLEDGMENT

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REFERENCES

[1] Dostálek, L., Kabelová, A. Understanding TCP/IP, Packet, Birmingham, 2006, ISBN 1-904811-71-0.

[2] Kováč, A., Halás, M. Vozňák, M. “Impact of Jitter on Speech Guality Estimation in Modified E-Model,” *12th International Conference Research in Telecommunication Technology RTT 2010*, Velké Losiny, Czech Republic, VŠB Ostrava, September 8 – 10, 2010, 225 p. ISBN 978-80-248-2261-7.

[3] Mišuth, T., Baroňák, I. "Performance Forecast of Contact Centre with Differently Experienced Agents," *Elektrorevue*. ISSN 1213-1539. Vol. 15, 16.11.2010 (2010), art. no. 97.

[4] Baroňák, I., Mičuch, J. "Preventive Methods Supporting QOS in IP," *New Information and Multimedia Technologies. NIMT - 2009: Brno*, Czech Republic, 17. - 18. 9. 2009. Brno: Brno University of Technology, 2009. ISBN 978-80-214-3930-6. pp. 15-23.

[5] Balogh, T., Medvecký, M.: Comparison of Priority Quauing Based Scheduling Algorithms. In: Elektrorevue, vol. 15, 16.11.2010 (2010), art. no 93. ISSN 1213-1539.

[6] Wootton, C. "A practial guide to video and audio compression," *Focal press*, USA 2005, ISBN 0-240-80630-1.

[7] Peško, S. "System queuing theory," 2001, http://frcatel.fri.uniza.sk/users/pesko/OA2/oa2m.pdf

[8] Hayes, J. F. et al., "Modeling and Analysis of Telecommunications Networks," Wiley Interscience, 2004.

[9] Iversen, V. B. "Teletraffic Engineering Handbook," COM Centre, Technical University of Denmark, 2001.

[10] Graf, T., Maxwell, G., Mook, R. "Linux Advanced Routing & Traffic Control," 2004 http://lartc.org/

[11] Thomas, K. "Beginning Ubuntu Linux From Novice to Professional," *Apress*, 2006, ISBN 1-59059-627-7.

[12] Bauer, M. "Building Secure Servers with LINUX," O'Reilly, 2003, ISBN 0-596-00217-3.

[13] Hunger, S. "Debian GNU-Linux Bible, Hungary Minds," New York, 2001, ISBN 0-7645-4710-0.

[14] Kist, A. "Erlang B as a Performance Model for IP Flows Networks," *15th IEEE International Conference*, 2007, ICON 2007.

[15] Hofmann, M., Beaumont, L. "Content Networking," *MK Publishers*, San Francisco, 2005, ISBN 1-55860-834-6.

[16] Davies, G. "Designing and Developing Scalable IP Network," *John Wiley & Sons Ltd*, England, 2004, ISBN 0-470-86739-6.

[17] Held, G. "Ethernet Networks – Fourth Edition," *John Wiley & Sons Ltd*, England, 2003, ISBN 0-470-84476-0.

[18] Plumley, S. "Home Networking Bible," *John Wiley & Sons Ltd*, England, 2004, ISBN 0-7645-4416-0.

[19] Pirogov, V. "Mastership in assembler language," *Computer Press*, Brno, 2005, ISBN 80-251-0888-0.

[20] Pirkl, J. "Network programming in Windows and internet programming," *Kopp*, České Budějovice, 2001, ISBN 80-7232-145-5.

[21] Chalupa, R. "1001 tips and tricks for Visual C++," *Computer Press*, Brno, 2003, ISBN 1-904811-71-0.

[22] Tisovský, A.: Method for Throughput Interpolation of Computationally Intensive IPsec Process. In: Telecommunications and Signal Processing TSP-2010 : 33rd International Conference on Telecommunications and Signal Processing. Baden near Vienna, Austria, 17.-20.8.2010. - Budapest : Asszisztencia Szervezö Kft., 2010. - ISBN 978-963-88981-0-4.

[23] Balogh, T., Medvecký, M.: Performance Analysis of Priority Quauing Based Scheduling Algorithms. In: Telecommunications and Signal Processing TSP-2010 : 33rd International Conference on Telecommunications and Signal Processing. Baden near Vienna, Austria, 17.-20.8.2010. - Budapest : Asszisztencia Szervezö Kft., 2010. - ISBN 978-963-88981-0-4. pp. 228-233.

[24] Tisovský, A., Kľúčik, S. Method for Calculation the Packet-Size Dependent throughput of a Computationally Intensive IPsec Process. In: Elektrorevue, vol. 15, 16.11.2010 (2010), art. no 98, ISSN 1213-1539.

[25] Voznak, M., Rozhon, J. Performance testing and benchmarking of B2BUA and SIP Proxy. In: 33rd International Conference on Telecommunication and Signal Processing, AUG 17-20, 2010 Vienna, Austria, pp. 497-503.

Inquiry-based learning in science enhanced by digital technologies

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Abstract— **The science education in Slovakia currently faces the new curriculum reform that emphasizes the role of scientific inquiry in education that is in good correspondence with massive European movement oriented on implementation of Inquiry based science education. As many researches show, the implementation of digital technologies into science education can help a great deal in the process of scientific inquiry. The contribution presents the key ideas of inquiry-based science education with concrete examples in physics education as well as the projects currently running in Slovakia in this field. The Slovak national project Modernization of education at primary and secondary schools is aimed at the implementation of new ways of education enhanced by ICT. This project is in a good consonance with the European 7FP project Establish with Safarik University in Kosice as a partner institution that is aimed at the use of IBSE elements in classes across Europe.**

I. INTRODUCTION

The science education in Slovakia currently faces new challenges connected with the new curriculum reform running from 2009. The reform emphasizes the role of scientific inquiry in education that is in good correspondence with massive European movement oriented on implementation of Inquiry based science education (IBSE). As many researches show, the implementation of digital technologies into science education can help a great deal in the process of scientific inquiry. However, the digital technologies itself cannot help in better understanding of scientific concepts. Their effective use strongly depends on the teaching methods used in the class. As research shows, traditional methods such as lecture, problem solving, traditional labworks cannot survive in the classroom in the world of all the technologies that our students are able to handle easily in their everyday life. The school of the 21st century has to reflect these trends. And it is not only about trends. In addition, purposeful and appropriate application of digital technologies in science offers students to assist and progress their learning and to engage them in higher-order thinking skills.

However, to implement IBSE enhanced by digital technologies in classrooms is not an easy task. The success of the educational reform requires consonance of many elements to be taken into account, such like improvements in teacher training, change in curricula and student assessment as well as instructional materials available for easy use of teachers.

II. INQUIRY-BASED SCIENCE EDUCATION

A. *What do we mean by scientific inquiry?*

There are many interpretations to the questions – What do we mean by scientific inquiry? A possible short answer is that it is the systematic and principled process of pursuing and refining explanations for phenomena in the natural or material world. According to Linn, Davis and Bell [1] "Inquiry is the intentional process of diagnosing problems, critiquing experiments and distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers and forming coherent arguments". The national Science Education Standards [2] describes inquiry as the way scientists do research and presents this as an inquiry cycle (fig.1), while Llewellyn [3] describes it as inquiry-oriented learning where the principles of constructivism are acting as the foundation for understanding inquiry (fig.2).

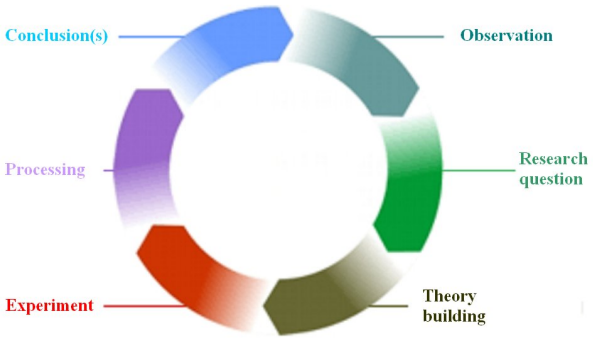

Figure 1. A 6-stage cycle for inquiry investigations and modeling [1].

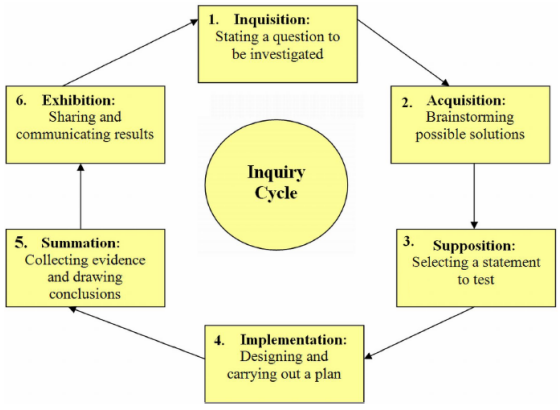

Figure 2. A 6-stage cycle for inquiry cycle [3].

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Although, many different types and levels of inquiry-based teaching and learning are available, it is widely agreed that inquiry-based teaching is an organized and intentional effort on behalf of the teacher to engage students in inquiry-based learning. The goal of inquiry teaching is not to transfer scientific knowledge, facts, definitions, and concepts, but rather to enhance students´ ability to reason and to become independent learners who are capable of identifying main questions and find relevant answers by a gradual acquisition and expansion of a body of scientific knowledge and abilities. It is a student-centered approach to science learning.

B. Types of inquiry-based activities

In all types of inquiry activities the most important principle is to decrease the teacher activity and participation and to increase the student activity. The levels of inquiry-based activity differ by the amount of teacher/material guidance, student independence and developed skills [4].

According to that there can be several types of inquiry activities, namely:

1. Interactive discussion /Interactive demonstration: the teacher is in charge of posing the question or conducting the demonstration and manipulating a scientific apparatus.
2. Guided discovery: same as the interactive demonstration, but in this case the students carry out the experiment introduced to them by the teacher. It is the traditional student laboratory work, mostly in the form of cookbook labs or work driven by step-by step instructions. Usually, this concerns a group activity simultaneously carried out by the whole class with a strong focus on verifying information previously communicated in class.
3. Guided inquiry: in this case, students work in teams on their own experiment. The teacher has identified the problem and has given a clear-cut objective: "Find...", "Determine..." There is no predetermined answer and conclusions are solely based on student work. Students are given directions or extensive (pre-lab) instructions, and they are guided by multiple teacher-identified questions.
4. Bounded inquiry same as in the above, but in this case students are expected to design and conduct the experiment themselves with little or no guidance of the teacher and only partial pre-lab orientation. The research problem to be solved is given to them by the teacher, but they have the responsibility for designing and conducting an experiment. Bounded inquiry activities require a definite level of experience from the students, otherwise they could get lost.
5. Open inquiry: within a given context, the student is expected to propose and pursue their own research question(s) and experimental design. This will usually be a semi-final assignment of senior students. Example: "Setting up an experiment for speech analysis or recognition". Students can either compare high or low tones, male or female, produced by musical instrument or vocally, loud or soft, etc.

III. INQUIRY-BASED SCIENCE EDUCATION AND DIGITAL TECHNOLOGIES

As many researches show, the implementation of digital technologies into science education, if used in an appropriate way, can help a great deal in the process of scientific inquiry. However, the digital technologies themselves cannot help in better understanding of scientific concepts. Their effective use strongly depends on the teaching methods used in the class. In science education the "inquiry" approach is connected mainly with all kinds of experimentation. Concerning the experiments in science, digital technologies play an important role in collecting, processing and analyzing data. Consequently, as used in science, it becomes a natural part of school experimentation. In science education, real-time experiments with datalogging (using interface and sensors), remotely-controlled experiments, experimentation on videoclips, and virtual experiments with the help of computer simulations have their strong educational benefits. Digital technologies in this sense can enhance inquiry approach to teaching and learning since:

- It supports active learning environment allowing students to work in a similar way as scientists do in their laboratories
- It encourages critical thinking skills. Students have more time for exploration and analyzing results since distractions and lower-level student chores during the laboratory are reduced.
- Frequent interaction and feedback is one of the most important features of experimentation supported by digital technologies. The immediacy of feedback allows students to "self-regulate their learning" towards more individual learning without fulltime supervision of the teacher
- It encourages students' collaboration and peer instructions while discussing and analyzing results.

IV. EXAMPLES OF IBSE ACTIVITIES ENHANCED BY DIGITAL TECHNOLOGIES IN PHYSICS

A. Interactive discussion/ demonstration

This activity is carried out by the teacher with active student participation that can be supported by a prediction sheets where students make predictions and answer questions about the experiment presented by the teacher. Even if the experiment is carried out by the teacher, the experimental procedure involves student to participate, make predictions, think, compare and make conclusions.

In fig. 3 there is an example of interactive experiment on the Archimedes principle using force sensor to measure the force on it while submerging a body into water.

A cylinder of density greater than the density of water ($\rho_{cylinder}>\rho_{water}$) is hung from a force probe with a rigid rod. It is lowered slowly into a container of water. Sketch your prediction for the force probe reading as a function of time. Be sure to include the initial reading before the cylinder touches the water, and also the reading when the cylinder is completely submerged.

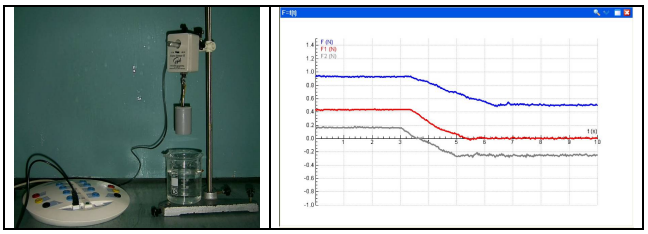


Figure 3 Example of a part of a demonstration worksheet, experimental setup and results gained by measurement.

B. *Guided discovery*

Students working in groups of 2-3 explore the uniform motion of a sailor or uniformly accelerated motion of a cyclist. Students verify previously introduced kinematic concepts and relationships following step to step instructions in their worksheets (fig.4).

Measuring procedure:
Play the video. Describe the sailor´s motion.
Measure the position of the sailor (choose as a video point location).
The video is already scaled (4m horizontal ruler on the sailboat, frame rate of 5 frames per second).
The horizontal position versus time graph of your measurements appears on the screen.

Assignment:
Describe the motion of the sailor.
What was the initial position of the sailor?
What was the final position of the sailor?
How long was the motion?
What can you deduce about the sailor's speed?

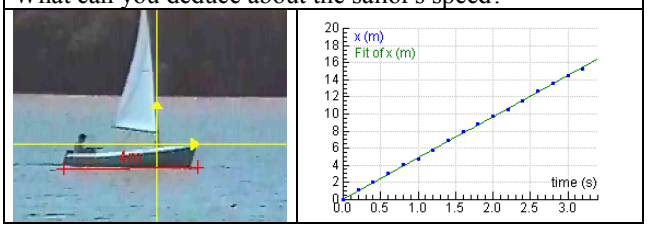


Figure 4. Example of a part of the uniform motion guided discovery worksheet, scaled video screenshot and experimental results.

C. *Guided inquiry*

Students are given a problem, e.g. what the bungee jumper fall looks like. Students working in groups of 2-3 can be given directions or extensive instructions in the worksheet. They can do the investigation on the prerecorded videclip or a real experiment with a weight attached to the rubber string (fig.5).

D. *Bounded inquiry*

Students are given a problem, but the way how to solve it has to be decided by the students. They can be given just a small help. In fig. 6 there is an example from electricity about the changing brightness of two different bulbs in a dc circuit when closing the circuit. Students are given materials and they decide an experiment to carry out to explain this phenomenon. In this case they should understand that for the bulb brightness the power dissipated is crucial. Then they decide what quantities to measure and what to compare in order to draw conclusions.

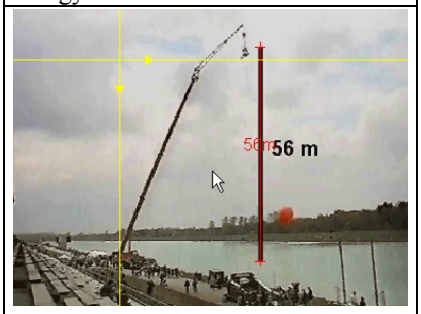
E. *Open inquiry*

In this case students learn to find and formulate their own research question without a strict guidance of their teacher. They learn to setup and successfully finish their own practical experiment and draw conclusions. In fig. 7 there is a part of the worksheet students get in order to do the open investigation.

Examples of research questions student could formulate concerning the human speech analysis:

- What, I any, is the difference in amplitude and frequency between vowels a, e, o and u? Which property can be used best to distinguish them?
- How to approach orally the sound of a tuning fork?
- Analysis and recognition of the sound pattern of the world Earth.
- How do we recognize gender in the same vowels a, e and u? Man versus woman.
- Comparison of the spectrum of a flute and a singing voice, producing the same note.

Find out:
How the position, speed and acceleration changes with time during the fall.
How the force acting on a jumper changes with time.
Check the validity of the law of energy conservation.



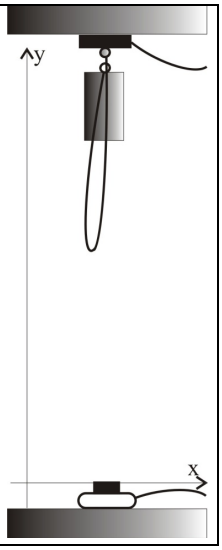


Figure 5. Example of a guided inquiry activity on the bungee jumper fall.

If we put two different bulbs in the holders one of them will light up later then the other. There is a noticeable delay between the two bulbs. Explain.

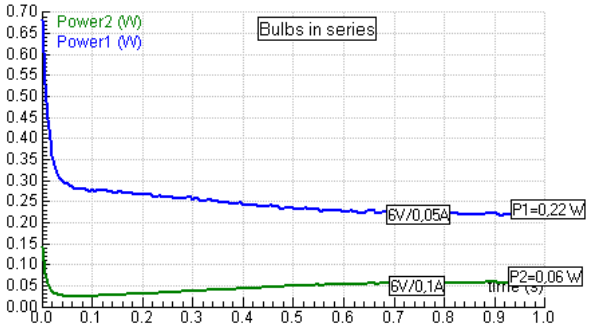


Figure 6 Example of a bounded inquiry on the bulbs behaviour and experimental results.

Human speech analysis dates back to the mid twentieth century and has been an active field of research ever since. Governments eagerly made and make use of it. Recently, commercial applications come into play as well, with the development of passive and active speech computers, robotics, automation and security.

This is an open investigation. Formulate a research question connected to sound signal analysis, which you would like to investigate. Perform your investigation to answer your research questions. Prepare a presentation about the results of your investigation for your classmates.

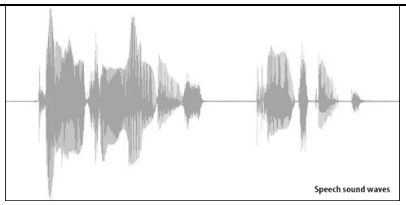


Figure 7 Example of a part of the worksheet aimed at human speech open inquiry activity.

V. Implementation of IBSE in Physics Classes

To implement IBSE enhanced by digital technologies in classrooms is not an easy task. The success of the educational reform requires consonance of many elements to be taken into account, such like improvements in teacher training, change in curricula and student assessment as well as instructional materials available for easy use of teachers. The currently running educational reform strongly emphasizes the necessity of scientific inquiry in physics education. On the other hand, very little has been done in order to wide successful implementation. There is still a lack of appropriate instructional materials and well-educated teachers. Teachers should understand what inquiry means, what activities they can carry out with their students, what levels are appropriate for their students, etc. in order to move from teacher-centered education to student-centered inquiry lessons and labs.

There are several national and international projects currently running in Slovakia trying to help in this field. The huge Slovak national project Modernization of education at primary and secondary schools [5] has already prepared instructional materials for the use of physics teachers [6, 7]. Within the project 543 physics teachers participate at 5 days course on how to develop competencies on the use of IBSE methods enhanced by digital competencies. The project activities are supported by e-learning platform offering a wide selection of instructional materials for an easy-use of teachers. The Slovak national project is in a good consonance with an international 7FP project ESTABLISH [8]. Within this project of a consortium of partners from 11 European countries there are instructional materials for teachers and students currently being prepared. This is followed by in-service and pre-service teacher training in this field.

VI. Conclusion

The success of the effective use of IBSE method enhanced by digital technologies in the class depends on the consonance of several elements that have to be taken into account. Change in curriculum and educational materials available for teachers are a good starting point. But this is not enough. The key element of the teaching process is a well-educated teacher who is familiar with the methodology of IBSE. Hence, the continuous in-service teacher training as well as pre-service teacher training is an inevitable assumption to the successful implementation of this way of teaching. Nevertheless, there are still some open questions, e.g. concerning student assessment within IBSE that have not been answered yet. However, the currently running projects activities indicate a promising start with a hopeful follow-up towards the expected changes in education.

Acknowledgment

We would like to thank all the co-authors of the publications The use of ICT in physics – primary schools and The use of ICT in physics - secondary schools for their cooperation. We also thank the partners of the international FP7 project Establish (No. 244749), for the motivation towards promoting the idea of Inquiry based science education. This work is the result of the national projects Modernization of the education at primary and secondary schools (ITMS project codes: 26110130083, 26140130013, 26110130084, 26140130014) supported by the European Social Fund as well as the international 7FP project ESTABLISH (European Union´s Seventh Framework Programme FP7/2007-2013 under grant agreement n° 244749).

References

[1] Linn, M.C., E.A. Davis, and B.-S. Eylon, The scaffolded knowledge integration framework for instruction, in Internet environments for science education M.C: Linn, E.A.Davis, and P.Bell, Editors.2004, Lawrence Erlbaum Associates: Mahwah, NJ p.47-72

[2] National Science Educational Standards, National Committee on Science Education Standards and Assessment, National Research Council, 1995, Washington, National Academic Press

[3] Llewellyn, D., Inquire Within, implementing inquiry based science standards, 2002, Corwin Press, Thousand Oaks, CA

[4] Wenning, C., Levels of Inquiry: Hierarchies of pedagogical practices and inquiry processes. 2005 Journal of Physics Teacher Education Online, 2(3), 3-11

[5] Slovak National Project Modernizácia vzdelávania na základných a stredných školách, available at https://www.modernizaciavzdelavania.sk/

[6] Ješková, Z. et col., *Využitie IKT v predmete fyzika pre stredné školy*, pre ÚIPŠ vydala Elfa, s.r.o. Košice, ISBN 978-80-8086-146-9, 2010

[7] Duľa, I. et col., *Využitie IKT v predmete fyzika pre stredné školy*, pre ÚIPŠ vydala Elfa, s.r.o. Košice, ISBN 978-80-8086-154-4, 2010

[8] Establish project, available at http://www.establish-fp7.eu/

Dynamic network reconfiguration based on application measurements with the goal of network traffic optimization

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***Abstract*—Problems of quality management of various types of communications in the IP network is becoming important increasingly, because of a growing amount of transferring data. This paper explains the basic operation of VoIP technology, problems concerning the reduction of transmitted voice quality caused by network load factor, and ways of solving these problems. This work also deals with methods for detection of network topology and automatic reconfiguration of network devices. The aim of this work is an automatic network reconfiguration in the interest of optimize VoIP traffic.**

***Keywords*—optimization, management, measuring, VoIP, IP network, detection, load balance, QoS, IP SLA, LDAP, CDP, SNMP**

I. INTRODUCTION

IP network is used for transferring messages demanding for low latency and for messages requiring error-free transmissions. Transmissions such as voice and video have significantly different requirements for transfering like computer data in the form of files, photos or documents [1]. To ensure the quality of the transmission, the Quality of Services (QoS) methods are being used. Individual communication links are not constant and it is necessary to dynamically adjust the rules governing the routing of data in the network.

In this paper the methods used for detection of network topology on the 3rd layer of the OSI model are analyzed. The search of alternative routes between routers, the valuation of lines, application optimization commands for routers and ongoing exporting of current information to an external server is also part of our solution.

The aim of this work is to develop a tool which will help network administrators to prevent poor quality on real-time communication and thus the poor clarity of human speech which is transmitted by VoIP technology assuming that the reduced quality is caused by overloaded communication links in the network.

II. GOALS

The goal of this work is to develop a fully autonomous software running on the background of operating system, where it can manage the quality of transmitted voice over IP network which is being monitored. With the goal of obtaining VoIP network parameters we have developed a VoIP analyzer. To communicate with the VoIP analyzer an own communication protocol has been developed.

III. ANALYSIS

A. Quality of VoIP Communication

For the purposes of achieving a certain quality of voice applications over the Internet, certain criteria for value of transmission parameters are required. Whereas calling is a real-time communication, the first place in requirements have low delay and jitter [1]. Those requirements are followed by low error rate, which may be delivery of damaged packets, delivery in a wrong order, or in the worst case packet loss rates. A list of basic network parameters and their requirements for the use of VoIP communication is seen in Table I.

TABLE I.
TYPE SIZES FOR CAMERA-READY PAPERS

Quality of sound	Excellent	Fair	Bad
bitrate [kbps]	2 – 64 (depending on the audiocodec)		
packetloss [%]	0-0,5	0,5-1,5	Above 1,5
delay [ms]	0-150	150-400	Above 300
jitter [ms]	0-20	20-50	Above 50

With the goal of achieving the required quality of a particular VoIP connection, increased priority for the network transition or distribution of data sent via multiple parallel paths can be configured.

Changing priority is a part of QoS techniques, which consists of the sign of each packet under its competence to transmission, which we want to influence. Identification is carried out on the basis of data (IP, port) about sender and recipient. For the marked packets the rules can be assigned for prioritized processing at routers [2].

Distribution of traffic on several routes leads to a reduction of bandwidth that is used for the current route. This method is called loadbalancing. Its implementation in this particular case was by using configuration of static routes (static routing has increased priority over the dynamic routing protocols) and load-sharing. This makes it possible to have rules on the network with an even

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higher priority for routing, for example policy based routing.

B. IP network topology discovery

CDP and SNMP protocols can be used with the goal of topology discovery [3]. For their utilization it is necessary to be active on each router to which it is necessary to communicate. The router's SNMP MIB database can be used to obtain any information about the router. The list of neighboring routers of active router is possible to obtain, when protocols SNMP and CDP are cooperating.

C. Valuation of lines quality

IP SLA service is the most suitable method to gather network parameters with the goal of analyzing qualitative parameters of network environment [5]. IP SLA is an intrusive method simulating a particular type of traffic on the network and the transmission parameters measured on this traffic provides a numerical rating. This result defines the current state of the line, which may be obtained from each router by SNMP.

D. Analysis of a VoIP connection

VoIP analyzer, which was developed as a part of this work, allows us to list ongoing active VoIP connections. This tool, based on sniffing SIP [4] and RTP packets, determines which call is currently active and also detects packet loss rates and delay variations of this communication. The resulting information is periodically sent by its own protocol to the newly - developed tool for managing network traffic ability.

E. Remote control of routers

SSH or telnet are protocols which are mainly used for remote administration of systems via interactive command line tool. This method also appears as the most appropriate method for automated control of routers using the software. Responses to the expected answers of devices during ssh connection is possible to solve by an external tool "expect" [6]. It processes in advance generated script that contain expected questions and responses to them.

F. Export of informations

All information gathered about the structure of the network and current ongoing calls should be exported to a standalone server for the possibility of usage in additional applications. Given the expected utilization of developed tool in place of Computer Networks Laboratory at the Technical University in Kosice, technology of directory services by LDAP server was selected [7]. This technology enables the creation of tree structure of objects and each object keeps certain information about itself.

IV. Solution and Results

A. Developed tool and testing environment

The final result of this work is the application environment called "Network Topology Tool"(NTT). This tool was programmed in C language and compiled out by gcc compiler. It is distributed in the form of a single deb package. After installing and restarting the PC, NTT starts during Linux boot process. After an automatic start, NTT is running in the background of OS in the form of a daemon. Setting up all necessary parameters can be done by a configuration file, which is always loaded when applications is launching. While program is running, the processing of procedures is possible to manage only by telnet connection. It is possible through telnet server compiled in NTT. This interface offers the ability to enter execution instructions for reconfiguration, restoring data to an LDAP server, display current information concerning the structure of IP networks, display information about current VoIP communications, etc. Detailed reports of actually performed actions can be observed in statements in the console, in which NTT is running.

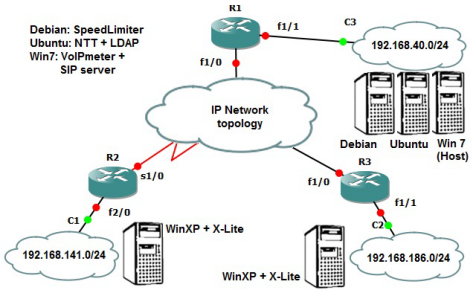

Figure 1. Software tools schematic layout

Figure 1 shows a schematic representation of a test environment. In this environment there were 3 final subnets. On subnet 192.168.40.0/24 was ran 3 PCs with different operating systems, as shown. Application Speedlimiter on Debian was used to generate synthetic traffic. Application VoIPmeter on Win 7 was used as a VoIP analyzer and sending out all the information of ongoing calls to the NTT via custom protocol named "Information Protocol VoIP"(VIP). SIP server has served as a registration server for SIP phones. On the Ubuntu system there was running the test application "Network Topology Tool" and LDAP server. Each of the remaining two subnets includes one Win XP with installed software SIP phone "X-Lite". All communication between subnets 192.168.141.0/24 and 192.168.186.0/24 has been redirected so that it passes through the network card in the system Win 7. With this modification it is possible to detect phone connection between the X-Lite phones using the VoIPmeter.

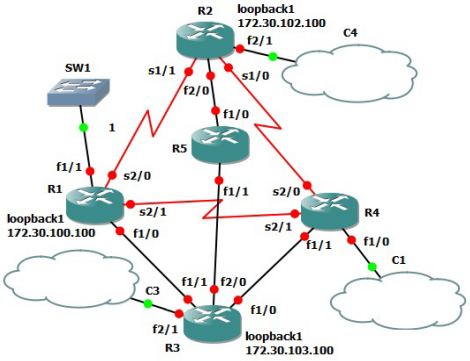

Figure 2. One of the test environment

Figure 2 shows one of the tested IP networks. These networks were used for testing the detection of structure, finding alternative routes between routers, as well as for automated reconfiguration of routers. In Figure 3 there is a segment of statement from telnet interface of NTT tool, which contains a text description of monitored network topology. Concrete, information of router R4 can be seen.

```
ROUTER: R4.GNS UNIQUE_SERIAL: ca-3-c-24-0-0
        IF NAME: FastEthernet1/0
        IF IP: 192 168 40 130
        IF IP_MASK: 255 255 255 0
        IF MAC: ca 3 c 24 0 1c
                VoIP Info:
                # Calls 0
                Link Icpif: 0
        -----------------------------------
        IF NAME: FastEthernet1/1
        IF IP: 172 20 0 43
        IF IP_MASK: 255 255 255 0
        IF MAC: ca 3 c 24 0 1d
                VoIP Info:
                # Calls 0
                Link Icpif:  1
        Neighbor: R3.GNS
        -----------------------------------
        IF NAME: Serial2/0
        IF IP: 172 20 103 45
        IF IP_MASK: 255 255 255 0
        IF MAC: 0 0 0 0 0 0
                VoIP Info:
                # Calls 0
```

Figure 3. An extract of the detected IP network by "Network Topology Tool"

B. *Progress and results of testing*

Testing optimization process based to the loadblanacing and QoS is the same, except the point where the mention of that specific method was used and in results of testing. The sequence of events during the testing of Automatic QoS reconfiguration of network topology to optimize VoIP communication was as follows:

1. Manual start NTT application environment and application VoIPmeter. NTT perform the whole initialization process (detect network topology, etc.).
2. Start a phone call between the X-Lite phones. VoIPmeter captures start of VoIP communication and detects communication ports for RTP transmission. This event is sent to NTT.
3. Transmission of RTP data with voice data in progress. VoIPmeter monitors the transfer and calculate transmission parameters, which are then sent to NTT.
4. Launch an application "Speedlimiter" for generating synthetic data to simulate network traffic.
5. NTT tool according to data from VoIPmeter detects that the packet loss and jitter rates increases. In excess of the threshold, automatic reconfiguration takes place. This is done by expect scripts with dynamicallygenerated instructions for setting Assured Forwarding and Expedited Forwarding, as part of QoS optimization.
6. After completion of optimization process, the transmission parameters of the phone connection return to normal.
7. Termination of VoIP connection. VoIPmeter detects this event and communicates it to NTT. The "Network Topology Tool" setup all reconfigured routers to its original form on the basis of information about completion of call connection.

The main difference in testing loadbalance optimization versus QoS optimization was, that sending packets through different routes, although the same qualitative valuation (such routes are the preferred by NTT tool), may cause delivery of packets in wrong order.

V. CONCLUSION

The aim of this work was to create applications, that will run on the background of linux operating system, where they will autonomously manage network traffic, focusing on optimization of VoIP communications.

With the tool "Network Topology Tool" is automatic detection of IP network structure available. With the information obtained directly from the network and with information of ongoing calls it is possible to automatically reconfigure a group of routers. This reconfiguration may be accomplished by distribution load or by increasing the priority of critical communications. QoS optimization provides the necessary effect of increasing the quality of transmitted voice. Method of loadbalance, in case of absence of buffer on the recipient side, could adversely affect quality of communication. For this reason it would be appropriate to replace the distribution of communications for redirect communication. Redirection would be undertaken through a less busy Path.

Suitable continuation of this work would extend its support for IPv6, or addition program based on updated data on LDAP server for drawing the entire network topology and displaying parameters of elements.

VI. ACKNOWLEDGEMENT

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VII. REFERENCES

[1] WALLACE, K. VoIP bez pedchozch znalost. translated by J.Gregor. $1st$ ed. Brno: ComputerPress a.s., 2007. 231 p. ISBN 978-80-251-1458-2

[2] WANG, Z. 2001. Internet QoS : architectures and mechanisms for Quality of Service. San Francisco: Morgan Kaufmann Publishers, 2001, 239 p. ISBN 1-55860-608-4

[3] MAURO, D., SCHMIDT, K. Essential SNMP. $2nd$ ed. Sebastopol: O'Reilly Media, 2005. 460 p. ISBN 0-596-00840-6

[4] RUSSELL, T. 2008. Session Initiation Protocol (SIP): Controlling Convergent Networks. New York: McGraw-Hill Companies, 2008. 264 p. ISBN 0-07-148852-9

[5] CISCO SYSTEMS, Inc. Cisco IOS IP SLAs Configuration Guide: Release 12.4. San Jose: Cisco Systems, Inc., 2008. 271 p.

[6] LIBES, D. Exploring Expect. Sebastopol: O'Reilly Media, 1994. 608 p. ISBN 978-1-56592-090-3

[7] VOGLMAIER, R. 2004. The ABCs of LDAP: How to Install, Run, and Administer LDAP Services. Boca Raton:Auerbach Publications CRC Press Company, 2004. 440 p. ISBN 0-8493-1346-5

Reverse Engineering as an Education Tool in Computer Science

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***Abstract* - The concept of Reverse Engineering is used in many fields of IT every day, to name just a few: legacy compatibility, binary code patching, malware analysis, network protocols analysis, debugging or even rapid prototyping. Despite its broad use, reverse engineering is not actively taught as a part of computer science courses. This paper tries to provide a survey of some of the real life usage scenarios of reverse engineering, analyzes what skills and ways of thinking are developed by reverse engineering and provides examples how reverse engineering could be taught by practical problem solving, introducing creative thinking models and strategies. We focus on the importance of reverse engineering as a tool to ignite the self-motivation of students and systematically build their logical thinking capabilities and analytical skills.**

I. INTRODUCTION

Since the beginning of time the natural way of thinking was to "reverse engineer" the nature; flame, tools, Newton's apple, nuclear fusion all of them are just examples of understanding an external process, not necessarily deep understanding but enough to be able to use it for our own purpose. For thousands of years man did not understand the chemical process of flame and we still don't know if gravitation has its own particle or not. We look at these processes as black-boxes, describe experimentally determined properties and just use them. Such way of thinking is called top-down - it starts from a complex system and tries to decompose it into sub-parts [1, 2, 3, 4]. This way reverse engineering allows to focus only on the important detail through abstracting all - for the given task - unimportant details, for example use the fire to cook without caring about how it works. Interestingly, the whole education system takes the opposite approach - "forward engineering" - builds from scratch, layer upon layer of adding complexity, which is also called a bottom-up approach. We don't aim to replace the current system, we just want to provide a different point of view that is normally not taught and as we will show can be helpful in various situations where it can solve normally unsolvable problems or greatly reduce the complexity of the solution.[1]

II. REVERSE ENGINEERING

The practical aspects of Reverse Engineering (RE) were already studied deeply in the thesis *Software reverse engineering education* by T. Cipresso (San José State University) [5]. Cipresso divides RE into two categories: Software development related and Security related as shown on Figures 2 and 3. He also states that one of the strongest motivations why teach RE is Legacy software maintenance and proves his point by stating that about 70% of the source code in the entire world is still written in COBOL: *"Since it's cost-prohibitive to rip and replace billions of lines of legacy code, the only reasonable alternative has been to maintain and evolve the code, often with the help of concepts found in software reverse engineering."* Figure 1 illustrates the process of maintaining legacy software systems.

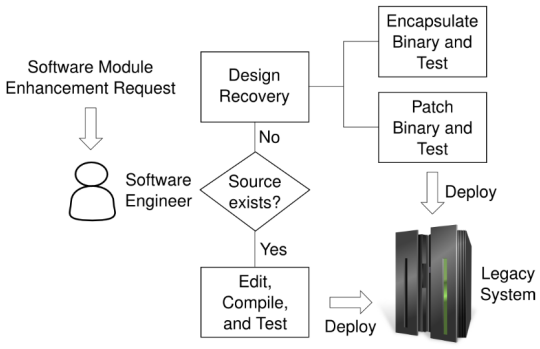

Figure 1. The process of maintaining legacy software systems

Development related software reverse engineering scenarios include:

- **Achieving Interoperability with Proprietary Software:** Develop applications or device drivers that inter-operate (use) proprietary libraries in operating systems or applications.
- **Verification that Implementation Matches Design:** Verify that code produced during the forward development process matches the envisioned design by reversing the code back into an abstract design.
- **Evaluating Software Quality and Robustness:** Ensure the quality of software before purchasing it by performing heuristic analysis of the binaries to check for certain instruction sequences that appear in poor quality code.
- **Legacy Software Maintenance, Re-engineering, and Evolution:** Recover the design of legacy software modules when source is not available to make possible the maintenance, evolution, and reuse of the modules.

[1] For the purposes of this paper we will use the term "Reverse Engineering" (RE) as a synonym for Software Reverse Engineering (SRE) and Reverse Code Engineering (RCE)

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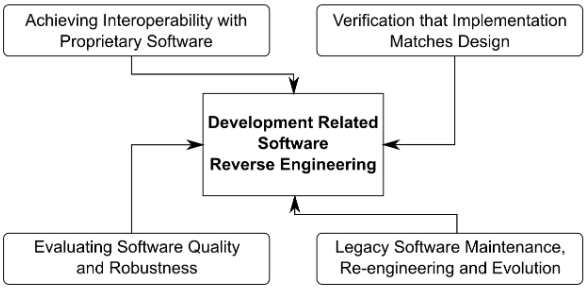

Figure 2. Development related software reverse engineering scenarios

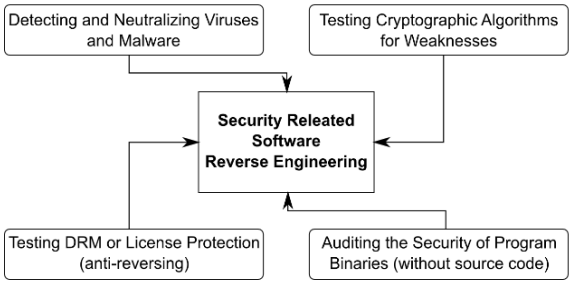

Figure 3. Security related software reverse engineering scenarios

Security related software reverse engineering scenarios include:

- **Detecting and Neutralizing Viruses and Malware**: Detect, analyze, or neutralize (clean) malware, viruses, spyware, and adware.
- **Testing Cryptographic Algorithms for Weaknesses:** Test the level of data security provided by a given cryptographic algorithm by analyzing it for weaknesses.
- **Testing DRM or License Protection (anti-reversing):** Protect software and media digital-rights through application and testing of anti-reversing techniques.
- **Auditing the Security of Program Binaries**: Audit a program for security vulnerabilities without access to the source code by scanning instruction sequences for potential exploits.

III. Reverse Engineering in Education

Some universities already tried integrating Reverse Engineering techniques with traditional computer science courses; one example is the University of Missouri-Rolla. The results were very encouraging, 77% students indicated that introducing reverse engineering methodology reinforced concepts taught during lectures. Furthermore, 82% wanted it to be blended in future courses, especially those that dealt with design [6].

Both mentioned approaches (San José State University and University of Missouri-Rolla) are trying to integrate reverse engineering into their coursework by focusing only on its practical usage completely disregarding its deeper pedagogical value which we are going to explore in the following text.

Motivation comes in two forms, intrinsic and extrinsic [7]. We are going to cover the intrinsic motivation also called: self-motivation, which is the ability of oneself to push and continue on a path even when obstacles are encountered without influence from other people. Clearly self-motivation is a critical trait of a successful engineer and is necessary to be able to solve problems independently. We argue that self-motivation is to some extent a learned trait, learned by experience.

As a matter of fact we are not the first to formulate this idea as a famous quote by Admiral William Halsey proves: *"There are no great men, only great challenges that ordinary men are forced by circumstances to meet."*

Imagine being repeatedly forced to overcome all expectations. Overcome your own limits and do what you never thought possible. By the repeated exposure to this practice build self-confidence and boost ego. Ego boosting is naturally addictive and thus a form of self-motivation to overcome challenges [7]. Reverse engineering is perfect for ego boosting because results can be obtained fast and without vast prior knowledge.

To prove this statement we could look at why RE is so popular amongst certain engineers. An example of a group that reverse engineers software for enjoyment is CORE which stands for "Challenge of Reverse Engineering" [8]. Another example could be the recent high-profile hacking attacks of LulzSec, who draw their name from the neologism "Lulz", (from LOLs), "laughing out loud", which often signifies laughter at the victim of a prank, and "Sec," short for "Security" [9]. The same factors that motivate these engineers to take the extreme risks of high-profile hacking/cracking could and should be used in a controlled manner to motivate students.

Classical learning approach of forward engineering could be then compared to reverse engineering as learning for success to learning through success.

This logic can be simply demonstrated on an example RE task, an application binary is provided and the students are asked to change the behavior of the application without access to the neither source code nor documentation. The only technique applied is the execution flow control using a debugger[2]. A very basic knowledge of the Assembler programming language is required so that the students can monitor and control the chain of execution[3]. Students need to explore the behavior of the application, use analytical skills to identify which part of it is important to focus on, find the

[2] For example using OllyDbg which is an x86 debugger that emphasizes on binary code analysis, which is useful when source code is not available.

[3] Basic knowledge of jumps, calls and returns should suffice.

corresponding code and trace the execution flow until they realize the exact instructions defining the application behavior that they have been asked to modify. Using a systematic experimental approach they modify the localized set of instructions and monitor the resulting behavior until the given goal is accomplished. The students just created their first binary patch, or we could say their first software "crack"[4]. We suppose the broad majority of students although came into contact with software "cracks" never thought they would be able to create one on the first lesson of a course.

The same scenario can be varied depending on the level of prior knowledge of the Assembler language for example the execution flow could be diverted by understanding the logic comparisons and changing the "cmp" instructions accordingly. Or a "key generator" could be reverse-engineered based on the understanding of the key verification process.

The subject of reverse engineering is not limited to dissecting application binaries, network protocols are an interesting target too. We could look at them as on input/output of an application and by understanding them, understand the application. Transport Layer Security (TLS) resp. Secure Socket Layer (SSL) are the most commonly known cryptographic protocols that provide communication security over the Internet. They are used in applications such as web browsing, electronic mail, Internet faxing, instant messaging and voice-over-IP (VoIP). The students could be asked to reverse engineer an SSL-protected protocol using a network proxy[5]. Analyze it and either simulates a Man-in-the-Middle attack or a client that could use the network provided service without the original software. Again, analytical thinking would be required to manage the "complexity" of the protocol, focus at one layer of complexity at a time and work their way down through it. With only limited prior knowledge the students would accomplish to "hack" a protocol protected with the same mechanism that protects most of the Internet within a single lesson. Of course the goal is just to open the door for the students, so that they realize they are able to accomplish more than they thought. Further exploitation of the protocol could be given as homework; the most creative student could be rewarded.

As already mentioned, the top-down approach employed by reverse engineering is extremely valuable for example also for rapid prototyping. Let's say the students would be given the task of prototyping a system too complex to develop from scratch, further they would be given only a very limited time to fulfill the assignment. The only way how they could manage would be to look for existing solutions like libraries or whole applications which they could combine to create a system with the desired functionality. To make the educational point clearer they would not need to make it actually run, but just understand the API or functional parts and be able to combine them using pseudo-code. The simplest and most elegant solution should be rewarded. This way the students would realize that it is possible to accomplish far more than they thought in a limited time frame by dissecting a complex system into sub-parts and reusing existing solutions.

[4] Software cracking is the modification of software to remove or disable features which are considered undesirable by the person cracking the software.

[5] For example the Fiddler debugging proxy could be used to analyze and simulate protocol behaviour without the need to write a single line of code.

IV. CONCLUSIONS

If we define hacking as the art of creative problem solving [10], reverse engineering is the art of problem dissecting and thus a critical part of any efficient problem solving process. In this paper we presented ideas how reverse engineering can be used to ignite student self-motivation, systematically build their logical thinking capabilities and analytical skills. With the exponential growth of the amount of information necessary to solve IT-related problems or to compete in the global workforce market, it is crucial to understand that there are only two options where the education system can be headed. Either try to compete with population rich countries like India or China using the traditional bottom-up approach focusing on skills and information that keep changing at a growing rate or try to augment the education system with techniques like reverse engineering to focus on teaching how to think creatively instead. We argue that with the right way of thinking and a systematical approach, all problems are solvable. Reverse engineering is the art that teaches these skills. Due to its importance we sincerely hope that reverse engineering will be integrated into computer science education either as a standalone course or as a part of existing courses.

ACKNOWLEDGMENT

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REFERENCES

[1] Niklaus Wirth, "Program development by stepwise refinement," *Communications of the ACM*, 14(4):221–227, April 1971.

[2] Gerald M. Weinberg. *The Psychology of Computer Programming.* New York: Dorset House, 1998.

[3] Eldad Eilam. *Reversing: Secrets of Reverse Engineering.* Indianapolis: Wiley, 2005.

[4] Mark Stamp. *Information Security Principles and Practice.* New Jersey: Wiley, 2006.

[5] Cipresso, Teodoro, *Software Reverse Engineering Education.* SJSU Master's Thesis, 2009.

[6] Muhammad Raza Ali, "Why teach reverse engineering?," *ACM SIGSOFT Software Engineering Notes*, v.30 n.4, July 2005.

[7] Bénabou, R. and Tirole, J, "Intrinsic and Extrinsic Motivation," *Review of Economic Studies*, 70: 489–520, 2003.

[8] Wikipedia (2011), "Reverse engineering," available: http://en.wikipedia.org/wiki/Reverse_engineering [accessed 15 Sep 2011].

[9] Wikipedia (2011), "LulzSec," available: http://en.wikipedia.org/wiki/LulzSec [accessed 15 Sep 2011].

[10] Erickson, Jon. *Hacking the Art of Exploitation.* 2nd ed. San Francisco, Calif: No Starch, 2008.

Curriculum as an event hierarchy model

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***Abstract*—Activity plays an important role in human life. Psychology as scientific discipline knows several categories of activities, motivations to activity, their characteristics etc. A significant group of these activities expects some cognitions, knowledge and skills. We identify particular relations, arrangement respectively event hierarchy, which is represented by expression of requested knowledge. Existing knowledge is not sufficient for execution certain activities. Therefore it is necessary to interact with the new content - holder of such knowledge. This paper provides an alternative way of identifying of content curriculum by analogy to the technology of Complex Event Processing and Event Driven Architecture. Identified content is a key in relation to national-education program creating as well as school-education program. Proposed method is implemented by modelling tool EDUMO.**

I. INTRODUCTION

There are already many different systems to support learning in the form of Learning Management Systems LMS, Content Management Systems and the like. Each has proposed ways to address curriculum content. However, none of them solve the problems of redundancy, reusability and maintainability of content curriculum. One of the objectives of our research was to verify the customary procedure (software modeling) of similar processes in other application domains and thus to work towards an outcome that could be described as the minimum required content of the curriculum model for achieving a certain level of education. Analogy of concept of Complex Event Processing CEP, Complex Event Hierarchies with events of normal human life (implementation of professional skills, the key competencies etc.) was the motivation to the way how to create models of desirable content curriculum. CEP as a relatively newly established technology for creating and managing information systems, including [4], monitoring business activities, management of business processes, integrate business applications, event-driven architecture, network security and business level, in compliance with real-time control and the policies used techniques for detection of complex patterns events in the event cloud processing streams of events, event correlation and abstraction, event hierarchies, and relations between events.

II. ANALOGY BETWEEN CEP AND CMS EVENT CONCEPT

During the process of learning a variety of events occur that affect its course and level of knowledge of the learner. Discrete events in certain combinations represent a composite - a complex event. For example, information security (treatment against the intrusion of SQL injection), GUI implementation with a box for username and password, editing the general conditions of use web site services, functionality for registration in the case that we haven't login data (we are not registered) may represent a decomposition of complex event. The complex event will be a requirement to implement the authentication form web site. Analogous to the approach applied in the EDA and CEP we can finalize the hierarchical structures in the area of the curriculum. Such processing of content will provide useful solutions - event handlers - useful throughout the life of a man. Learning process assumes a hierarchy in which the content of complex events can be broken down into elementary events. Complex event aggregates elementary events and present higher logical meaning than elementary events. Event is usually represented by an object, containing information on activities carried out in the system [4].

Event may be linked to other events. Event consists of 3 aspects:

- Form - Form event is an object which may contain attributes or data. Form may be something simple like a string or a complex tuple data. This data may include data such as: the implementation period of activity, place of origin, source of an event, a description of importance and dependencies.
- Significance – Event represents an activity. This activity is called the importance of the event. Event usually contains data that describe the importance of activities.
- Relativity - The activities are linked to other activities through time, causality or aggregation.

Example of a class of events may look like this:

```
Class InputEvent
  {
    Name NewOrder;
    Event_Id E_ID;
    Customer Id;
    OrderNo O_Id;
    Order (CD X, Book …);
    Time T;
    Causality (Id1, Id2, …);
  }
```

Relationships which may arise between events are as follows [4]:

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- Time relationship - defines the ordering of events in time. For example, event A occurred before event B.
- Causal relationship - to determine that event was triggered by another event. For example, event A triggered event B.
- Aggregation – if event A was triggered by more than one event e.g. B1, B2, Bn .. then A is referred to as the aggregated event and B1, B2, Bn are members of the event A. Event A is also called complex event.

An example of event hierarchy is graphically illustrated in Figure 1. Figure includes four events: Message sent, Message received, Acknowledgment and Message delivered.

The first three are causally dependent on each other. So the event Message sent binds report Message received, which then runs the adoption event Confirmed. These three events together are aggregated by the event Message is delivered. In CEP systems the event Message is received (complex event) is represented as a rule. Rule compliance checks three input conditions.

The analogy itself is a powerful means to solve problems, and based on the mimic. Software engineering was influenced by analogy to the architecture of buildings (see the work of Christopher Alexander). Later Clemens et al. used the software architecture analogy to a living

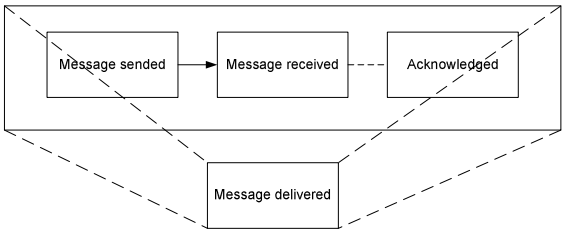

Figure 1. Event hierarchy of part a network communication

organism [1]. And so the analogy has become in our case means for identifying the minimum necessary content.

III. PROOF OF CONCEPT

For verification objectives we have designed a software tool EDUMO. With this tool, we suggested a few exemplary models. Figure 2 is a part of a model that captures complex event - function definition in certain programming language. The hierarchy consists of four events. There are events: Function without return value, Function with return value and Function with parameters. These are events at the lowest level. Functions with no return value and with return value are independent of each other. Function with parameters is causally dependent on both of them. While the student learns to create functions with appropriate parameters is important to learn how to create a function without parameters. These three functions are aggregated by the event Function definition. So if a student manages handling of the three events from the lower level he actually controls all types of function definitions. Aggregated events in the proposed software tool EDUMO are defined in declarative manner.

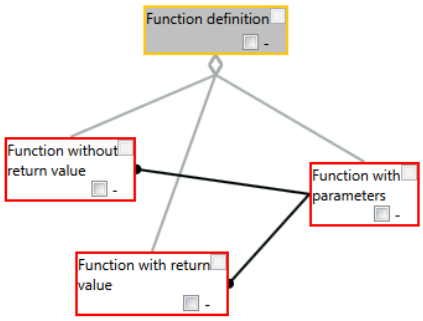

Figure 2. Function definition example

Let's analyze the example of an aggregate event of network communication environment as shown in Figure 1. There are three elementary events: Message sended, Message received and Acknowledged. These three events are aggregated by the event Message delivered, and this event is of higher logical importance.

A. *Complex event example*

A more complex example of events hierarchies is listed for the PHP language course at beginner level. The events in the hierarchy are drawn from the pages of W3C [6]. The whole hierarchy is divided into 3 levels, as shown in Figure 3. Event marked with the capital letter A is different from others because it is a prerequisite for the proposed event-whole hierarchy. It is assumed that a student who wants to undergo the PHP course passed the course of HTML. Complex event marked by the letter B represents the aim of the model. The complex event is a composite of low-level events. This event has already associated the learning content. This fact is indicated by the checkbox marked with the letter D. Point C marks an event that is optional. This means that for successful course is not necessary to control the content of that optional event.

In this event hierarchy can be traced similar features, which are also found in other programming languages. Events marked with a blue circle are events that are general in nature for most programming languages. Processing of such minimum event hierarchies makes "Event API" for different areas of learning. Such "Event API" could create something like a framework for creating curriculum.

B. *Collaboration*

In addition to the use of analogy to create curriculum we use to create the minimum necessary content and collaborative processing of identified events. Collaboration consists of two steps. The first step is manual. Created model contains all the events necessary to achieve the intended purpose. Identifying these events there is a cloud of events. To create a curriculum is needed at least two domain experts. Those following the identification of event Cloud create models of education according to their own ideas. This brings us several subjective models proposals. We assume that will not match. The second collaboration step is automatic. This step is based on an algorithm that performs penetration events and relationships of the available models. The result is the content which is acceptable to all involved.

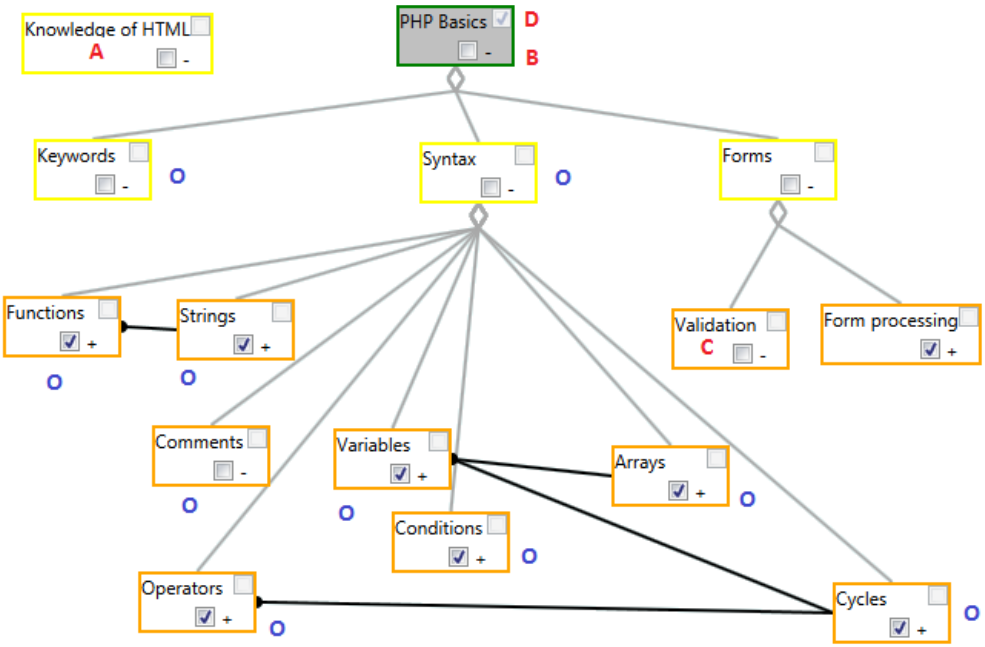

Figure 3. Learning model for PHP Beginer Course

Graphical representation of the collaboration using penetration of individual sets is shown in Figure 4.

As a result we get a model that exists in three different forms - graphical expression of models, XML file, in which the model is saved and the SCORM format

IV. Objectives

To check the proposed method, we set the following objectives:

- Evaluation of the proposed models specification
- Proposed models of the content
- Export to SCORM testing and compatibility with MOODLE LMS

During creating models of training, we tested the mutual compatibility of the proposed methods and modeling tools EDUMO.

A. Proposed models specification evaluation

In order to assess the accuracy of design models of training, we chose we chose to rewrite the content in

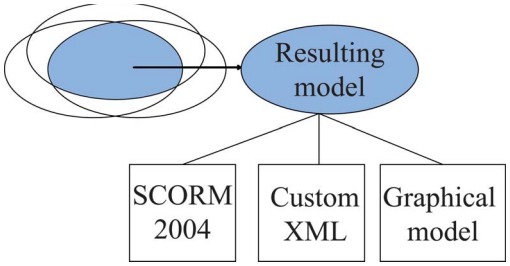

Figure 4. Resulting model of curriculum

language Z. The language Z is a mathematical language for formal mathematical description of requirements. In the Z language are written mostly aggregated operations, which are carried out during models design time. In the Z language definition of requirements we caught main operations that are carried out in the draft of models. These are simple operations like add your event, delete event etc. There are also more complex operations as an expression of the resulting events and the relations of the resulting collaborative model. To verify the accuracy of notation Z/EVES tool was used and all tests took place correctly. The result of evaluation is presented in Figure 5. Expression of the resulting events in the language Z is following:

```
\begin{schema}{GetIntersectedEvents}
    \Delta ModelEvents \\
    \Delta ResultModelEvents\\
    events1? : \power Events \\
    events2? : \power Events \\
    events3? : \power Events
\where
    resultEvents' = events1? \cap
    events2? \cap events3?
\end{schema}
```

B. Experimental models

During the investigation of the creation of minimum required education models we have developed several experimental models. These models were made collaboratively. When creating experimental models, we confirmed the hypothesis that people from the same area do not create the same model. Therefore, we consider it appropriate to use common features of available models. During designing the models borderline situations may occur. For example, all models will be completely identical. This is the ideal situation, but very unlikely. This case did not occur in our tests. It may also happen that the models are completely disjoint. If this occurs, it will be appropriate to examine the level of understanding of the intended objective. This case in our tests also did not occur.

C. *Export compatibility with MOODLE learning management system*

To integrate with existing systems, we opted to export

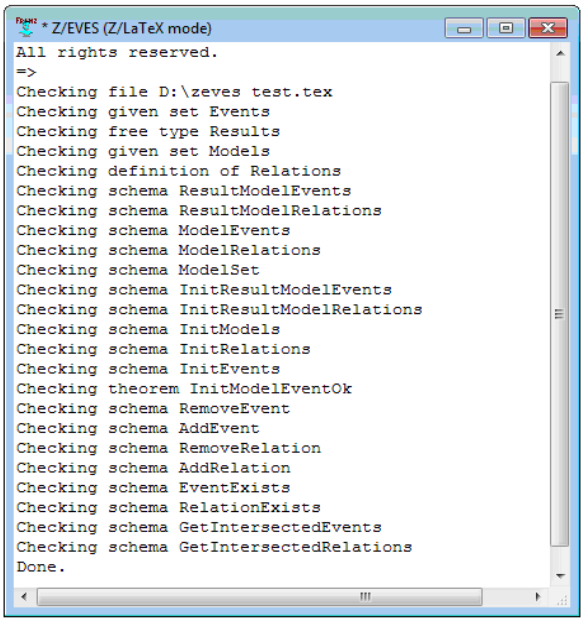

Figure 5. Requirement evaluating with Z/EVES

the model to education world-wide used SCORM format. Export to this format, we tested with the system MOODLE [5]. The course does not support testing and verification of knowledge yet. In the form in which it appears now, it serves just as a resource for learning. EDUMO tool can generate HTML documents containing the content bounded by final model.

V. Discussion

The result of this work is a method and tool for creating models of educational content. This describes the events necessary to achieve a certain degree of academic or professional education. When designing the method we took into consideration the ever-growing number of information which may include individual courses, and therefore we propose a method which could produce the smallest possible model. We have confirmed the hypothesis. People of the same environment created different models for the same goal. In proposed approach of minimizing the content of the curriculum is found a few problems that make them up:

- The problem of ensuring a unique identifier for an event
- The problem with the events generated outside the main hierarchy
- The problem of determining the necessary content
- Problem with model representation

The curricula and syllabuses are only in text form. Created models of education across text form have the following advantages:

- They are transparent – they allow maintenance of large content
- You can perform update without the duplication of parts
- Faster retrieval of information contained in the curriculum
- Easier to transform the model into another format
- Portability between systems
- Easier processes automation

VI. Future Work

For the creation of courses in the LMS-based content would be interesting to finalize the navigation in hierarchy for purposes of knowledge measuring and understanding of the hierarchy. User interface EDUMO is created in such a form that meets the necessary functionality and not always be user-friendly. Some actions should be resolved by mouse movements such as induction of forms and the like. Another interesting possibility could be the extension of LMS system that can process models created in their native form. Thus, a system that would create the management of established models.

VII. Conclusions

The work is based on the analogy between the CEP technology concept, the concept of EDA architecture and the concept of events for identification of curriculum content. Its minimal form, we have proposed to ensure by the collaborative approach. Given the fact that the models were neither identical nor disjoint, the theoretical assumptions of the minimum curriculum content form were confirmed in an embedded modeling tool EDUMO. The proposed models were transformed into formal mathematical description for the purpose of verification. To verify the accuracy of notation Z/EVES tool was used and all tests took place correctly. Finally we would like to make a recommendation for the specifications of the new LMS systems requirements. It would by very interesting to incorporate the support for modeling the curriculum content.

Acknowledgment

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References

[1] Clemens P. a kol.: Documenting Software Architectures. Views and Beyond 2nd Ed. 2010 Addison-Wesley. ISBN-13 978-0201703726

[2] Hrúz, B., Ondráš, J., Flochová, J.: Discrete event systems - an approach to education. Istanbul: The 4th Symposium on Advances in Control Education, July 1997. p. 14-16.

[3] Lang J., Kákody J.: Inovácia obsahu vzdelávania vzdelávacieho programu objektovo-orientovanou didaktickou transformáciou. Trnava: AlumniPress, 2009. SCHOLA 2009. p. 256-261. ISBN 978-80-8096-106-0.

[4] Luckham D.: The power of events. Boston : Addison-Wesley, 2007. ISBN 0201727897.

[5] MOODLE: [Online] [Date December, 5, 2010] http://docs.moodle.org/en/About_Moodle.

[6] W3C. Extensible Markup Language (XML) 1.0 (Fifth Edition). W3C. [Online] [Date November, 26, 2010.] http://www.w3.org/TR/REC-xml/.

Geogebra - a complex digital tool for highly effective math and science teaching

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Abstract — **Dynamic geometrical systems bring new tools for visualization and exploring mathematical ideas, structures and relations in teaching of mathematics. Among this type of systems the Geogebra is coming to the fore these days, thanks to its extensive options. In the methodical textbooks for teachers created within Slovak national project "Modernization of education at primary and secondary schools" Geogebra has an important position among used mathematical projects. This article introduces the main and the newest possibilities of the software environment Geogebra which joins dynamical geometry, work with algebraic expressions, graphs, spreadsheet, and the CAS environment into an unique unit that can be usable in teaching from primary school to university.**

Keywords — **Digital literacy, Education, Mathematics, Dynamic geometry software.**

I. INTRODUCTION

Meaningful and effective use of digital technologies in teaching process can help with stimulation of active learning and evolving of pupils' positive attitude towards math and learning. Teaching supported by computer should be based not only on integration of digital technologies into traditional ways of teaching, it should also respect the newest trends in the area of the teaching theory and the newest results of the development of digital technology.

In the suggestions of the teaching process of the mathematical themes in the methodical textbooks for teachers created within Slovak national project "Modernization of education at primary and secondary schools" are used various types of mathematical systems. The most common systems are:

- dynamic geometrical systems (Geogebra, Cabri II, Cabri 3D, C.a.R),
- CAS-type programs (Wolframalpha, Mathematica, Derive, Maxima) [1],
- spreadsheets (MS Excel, Google documents).

Digital technologies bring various potential options of the improvement of the teaching process to the education. The most proclaimed are:

- visualization – to increase the plasticity you can use static and dynamic graphical representation of the data that allow you to create the adequate visual imagination in pupils' minds
- interactivity and dynamics - in educational applications you can implement an immediate response to external stimuli in the form of providing feedback or dynamic changes of objects dependent on the altered parameters. Aspects related to the provision of interactivity and feedback are further elaborate in [2]
- use of models and simulations of the processes – using digital technologies you can create various types of models for the representation of the objects and mathematical structures and also you can execute simulation of the real processes.

All of the above also offer dynamic geometrical systems and therefore also math teachers often use these systems to create digital teaching materials and contraptions.

II. DYNAMIC GEOMETRICAL SYSTEMS

Dynamic geometrical systems allow you to easily construct geometrical shapes and by manipulation with the objects examine and discover invariant characteristics of the geometrical shapes and their mutual relations. Connection of the algebraically specified rates, geometrical shapes and animations represents strong tool for experimental examination of geometrical models of real situations and solving of various types mathematical problems.

In general, the main reason for the integration of dynamic geometry systems into the teaching of mathematics is creation of an experimental, interactive and dynamic environment conducive to active learning. However if we compare tools and possibilities of mentioned systems in introduction, it seems that Geogebra plays a special role.

The last version of Geogebra [3,4] became a powerful integrated software environment which combines in its views (windows): algebra, graphics, spreadsheet, CAS and construction all benefits of dynamic geometrical systems, spreadsheets, graphic calculators, CAS systems. Since these views are mathematically connected and work in perfect harmony, it makes from Geogebra so strong, complex and unique program that now it has very important impacts on pedagogy in math and science teaching.

For example it is known [5, 6] that typically after any traditional instruction connections among ideas, concepts, their formal representations, and the real world are often lacking. Because students can change interactively properties of exploring objects like lines, points or velocity or position vs. time graphs in any mentioned view and see simultaneously what these changes cause in remaining ones, Geogebra enables students to see mathematical ideas as „living, breathing moving".

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So that in any school subject using math this immediate feedback gives students the opportunity to develop deeper understanding than the traditional method of seeing only static objects on a blackboard or on PC in the separated types of software.

It is also quite amazing that at present Geogebra has tools developed in the project GeogebraTouch which adjust the program for using at Interactive whiteboard with all power of interactive whiteboards.

Previous Geogebra versions and applets created in them were designed for desktop computers and laptops. So they are not able to work on intelligent smartphones or tablets like iPhone, Android, Windows phone or iPad.

However current Goegebra project GeoGebraMobile [7] will soon allow the use of GeoGebra applets in modern web browsers both on computers and new mobile phones. This important step will permit students and teachers to use GeoGebra's large pool of dynamic materials on virtually all devices with a web browser.

Finally we should mention that Geogebra project called GeogebraTube will provide a very simple, easy direct upload of any applet for sharing with students and rating and commenting in worldwide pedagogical community.

III. Integration of Geogebra into the Methodical Textbooks for Math Teachers

In the methodical textbook the main tools of the chosen mathematical programs usable for support of math teaching are demonstrated. In the next part of the book the choices of using mathematical programs in extending of dominant ICT competences of pupils in math teaching are presented. ICT competences extended in separated dimensions of digital literacy are described in [8].

In extending the ICT competence Organizing data and explore relations the dynamic geometric systems and spreadsheet are mostly used. Solving problems using these programs can be part of systems of education elaborated in the form of interactive educating activities. As an example we can use educating activity created in author's system ToolBook Instructor focused on discovering the attributes of tangent quadrangle [2].

In solving some problems various software systems are used in separated steps of the solution. As an example we can use a problem from the second chapter of methodical textbook [9]: Children were building block stairs (see figure 1). Figure out with how many blocks the stairs in few next steps are built.

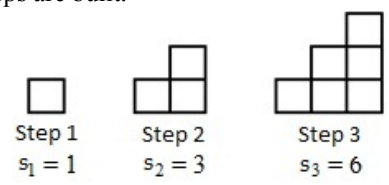


Figure 1. The first three steps of a building of stairs

For numerical and graphical representation of the data the spreadsheet MS Excel is used. For finding the number of the blocks in following steps of the building of the stairs it is easier to use recurrent relation:

$$s_n = s_{n-1} + n, \quad s_1 = 1.$$

Aforesaid relation indicates the fact that in nth step we add n new blocks to already built stairs. Recurrent relations are in the spreadsheet realized simply by defining formulas with links to vicinal cells. In the figure 2 there is a table created in described way along with graphic representation of the data.

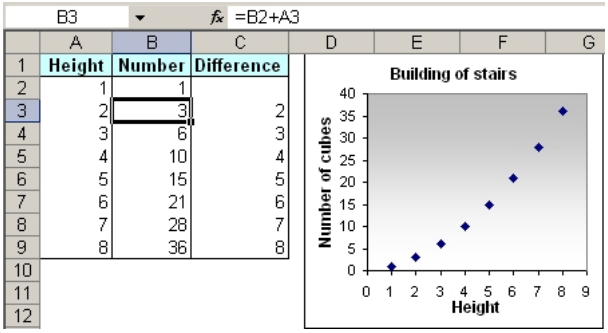


Figure 2. Numerical and graphical representation of data

From equally increasing difference between vicinal terms of the sequence we can say that the sequence indicates quadratic dependence. Analytical relation for calculating nth term of the sequence can be described in this form: $s_n = an^2 + bn + c, \quad a, b, c \in R.$

Deducing of analytical relation leads to the solution of system of linear equations with an unknowns a, b, c. For this purpose is possible to use CAS-type program. Mathematical program WolframAlpha, which is available online, will also formulate the analytic relation for calculating the nth term of sequence, after specifying the first few terms of sequence. This attribute is usable for checking of the results in the final step of solving the problem.

All the aforesaid programs are integrated into the program Geogebra, therefore all steps of solving the problem are realizable with this program. The sample of the possible solving of a problem using the program Geogebra is pictured in the figure 3.

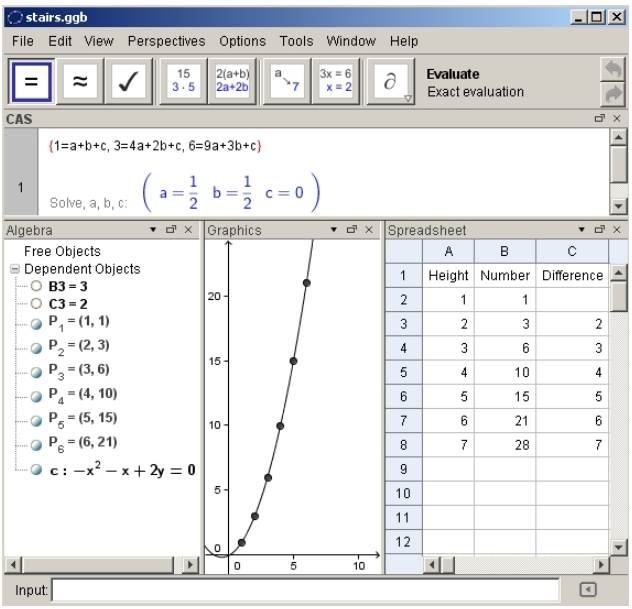


Figure 3. Solving of the problem in Geogebra environment

In the figure 3 there are pictured four main components of Geogebra, that are represented by Graphics, Algebra, Spreadsheet and CAS windows. Depending on active window the toolbar under the main menu adjusts. In the Spreadsheet window you can work with the data and use formulas and main functions in way similar to the program MS Excel. Data from the table are used for finding points using coordinates. Defined points are displayed in the Algebra window as depending objects. At the same time they are pictured in the Graphics window. The conic is brought forward through first five points, using the eponymous geometric order.

For defining coefficients a, b, c in analytical relation for calculating the nth term of the sequence we can use the first three terms of the examined sequence. Received system of linear equations is written and solved in the CAS window. The results imply that analytical relation for defining the terms of the sequence can be described in this form:

$$s_n = \frac{1}{2}n^2 + \frac{1}{2}n.$$

Analytical description of conic constructed in the Graphics window will be automatically listed among depending objects in the Algebra window. In this case the conic is parabola and is marked with c. For the set of all natural numbers is this description identical to the analytical relation for calculating the nth term of the sequence.

IV. GEOGEBRA IN THE TEACHING OF SELECTED MATHEMATICAL TOPICS

Diversity of tools of the program Geogebra enables to use this system to solve different types of mathematical problems in the methodical textbook for mathematics teachers [9]. We can demonstrate these possibilities by means of the section about using mathematical programs to model real situations. Geogebra is used for a modelling of ladder fall along a perpendicular wall and for the investigation of a track of the center of ladder during its movement.

An interesting application of mathematical modeling is the solving of linear optimization problems. The people often solve decision-making problems in real life. The solving of these problems requires finding of optimal solutions taking into account certain restrictions that can be often represented with linear inequalities. The geometric model can be used to solve mathematical model of a real situation in simpler cases. The solution is based on geometric representation of solution of linear inequalities system and of an investigation of target function values in points of a plane determined by means of geometric model. Software CAS or Geogebra can be used for these purposes.

The main part of the methodical textbook is the fourth chapter which contains suggestions for lesson plans of selected mathematical topics. Several mathematical programs, applets on internet, and other educational software systems are applied to solving of the problems in the methodical textbook. Interactive notebooks prepared using system Mathematica have an important role for educational treatment of the subject Elementary functions. Similar interactive mathematical documents can be created using Geogebra. We see the greatest possible use of GeoGebra for computer assisted learning of the following topics of the methodical textbook:

- **planimetry** – investigation of relationships between elements of the right triangle, investigation of modifications of Pythagorean theorem and its generalization, investigation of relationships between angles in a circle, identification of the set of all points in the plane from which a given segment is seen under the same angle,
- **Congruent and similarity transformations in the plane** – exploring the properties of axial symmetry and their application in problem solving, composition of axial symmetries, creation and investigation of the model of pantograf – real mechanical tool for zooming in and out of plane figures,
- **Elementary functions –** investigation of functional dependencies through their graphical representations, investigation of properties of functions, applications of linear, quadratic and exponential functions to solving of real problems,
- **Derivation of functions** – understanding concept of derivation of the function at a point using geometric meaning, investigation of derivations of elementary functions using graphical representations, investigation of the properties of functions using derivation, use derivations to solve real problems focused on finding extremes of functions,
- **Probability** – modelling of random events and analysis of the received results, estimation of the probability using the relative frequency, graphical representations of random events by geometric probability,
- **Statistics** – statistical data processing and their graphical representation, investigation of the relationships between data (e.g. fig.4)

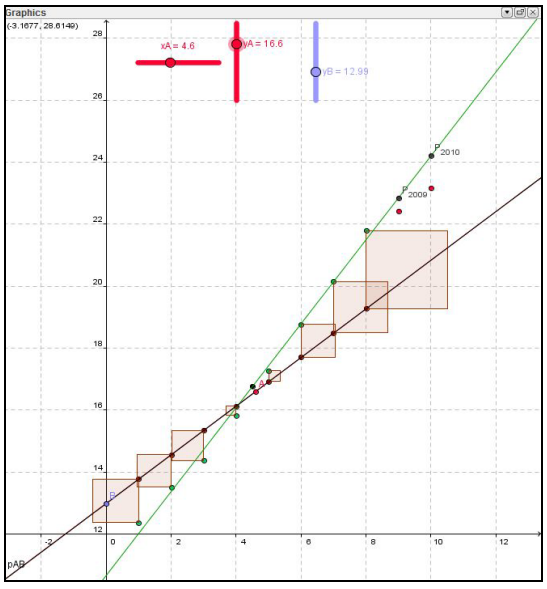
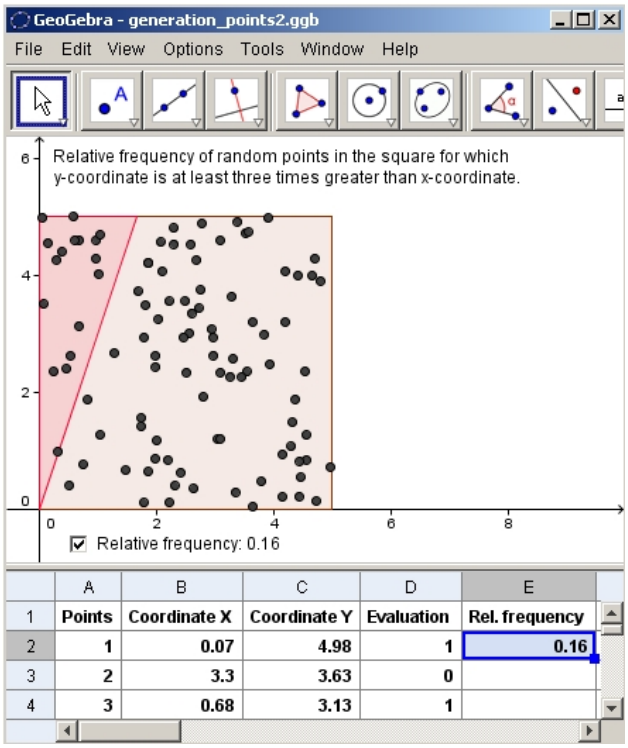


Fig. 4: Developing understanding of the least squares method in Statics.

The next section is focused on a detailed explanation of Geogebra application in estimating a theoretical value of probability using the method Monte Carlo and on a calculation of the probability of random events using geometric probability. We chose the following tasks from the methodical textbook: *Peter drew the points A, B, C, D with coordinates (0,0), (5,0), (5,5), (0,5) in the coordinate system. What is the probability that randomly selected point in the square ABCD has y-coordinate at least three times greater than x-coordinate?*

In the methodical textbook the estimation of the probability by means of modelling of random events is used at the beginning of problem solving. Spreadsheet Microsoft Excel is used to generate random points in the specified region of the plane, to evaluate the results, and to calculate the relative frequency. Geogebra can be also used to execute these operations. The parts of the solution are displayed in windows Graphics and Spreadsheet in the figure 5.



	A	B	C	D	E
1	Points	Coordinate X	Coordinate Y	Evaluation	Rel. frequency
2	1	0.07	4.98	1	0.16
3	2	3.3	3.63	0	
4	3	0.68	3.13	1	

Figure 5. Realization of the method Monte Carlo using Geogebra

The coordinates from the interval <0, 5> of one hundred random points are randomly generated in the window Spreadsheet in the columns B and C using the function Random between which is placed in the linear expression. The column D contains evaluation of the condition, whether y-coordinate of a random point is at least three times greater than x-coordinate. The formula IF[C2>=3*B2,1,0] is used for this calculation. The relative frequency of favorable results of the random event is calculated in the cell E2 after counting of favorable cases. New one hundred random points can be generated through pressing button F9. The coordinates of random points in the columns B and C are used to define points in the coordinate system and to display the points in the graph.

After the estimation of the value of probability we approach to the accurate calculation of probability using the definition of geometric probability. We use areas of the figures as geometric measure in the definition of geometric probability. We draw the square ABCD with the length of side equal to 5 cm with the vertex A in the origin of the coordinate system according to assignment of the problem. The square ABCD creates the sample space of the random event. The triangle AED represents favorable results of the random event. The borders of the triangle AED are formed by the sides of the square ABCD and by the segment AE containing the points which y-coordinate is three times greater than x-coordinate. Described situation is shown in the figure 6.

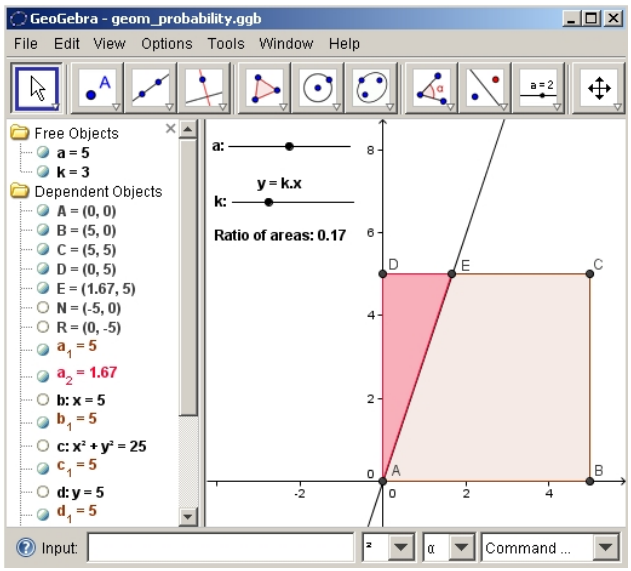


Figure 5. Use of the definition of the geometric probability

We can see in the figure 5 that a ratio of the areas of the triangle AED and the square ABCD equals 0.17. This value is just the probability of explored random event. The major advantage of prepared dynamic construction is the possibility to change the length *a* of the side of square ABCD and the slope *k* of line AE by means of the sliders. Students may satisfy that a change of the side length of square ABCD does not affect the value of the probability because created figures are similar with the same ratio of the similarity. The change of the slope *k* of line AE leads to showing of the results of analogical tasks which can be used to check students' solutions of the modifications of basic task.

V. Integration of Geogebra Teaching and Learning Materials for Science Subjects

Power and unique properties of Geogebra offer to use this software in any school subject applying mathematical ideas. For example in any area of physics like mechanics, electricity and magnetism, optics, relativity or quantum physics it supports very strongly all issues connected with one of four areas of digital and scientific literacy - creating and developing new ideas to understand the world around us by ICT and seeing how scientific method at this process works.

In physics especially understanding models and modelling by ICT were underestimated for a long time

and now in our modernization project belongs to main key-skills which should be developed in student minds.

In this contribution we would like to demonstrate two Geogebra applications in visualizing and applying mathematical models used in physics.

First of them is connected with applying physical model simultaneously with its visualization in solving the following physical problem: *A tennis ball is dropped from Pisa Tower. When it reaches the ground and what is its speed?*

The expected solution of the problem using digital technologies consists in the following steps:

- Students have to find in reliable information sources needed information. In this case height of Pisa Tower which is 55.86 m together with good picture of the tower.
- Then Geogebra image tool allows students to put an image of Pisa Tower in graphics view.
- The following direct manipulation with coordinate system allows calibrating the system to be corresponding to real measures of tower.
- After that slider tool containing time as independent quantity is used for simulation purposes.
- Next point A is put in the system as a model of tennis ball with any fixed x-coordinate and y-coordinate given by free fall formula applied in this case: $y = 55.86\text{-}5t^2$.
- Finally activating animation property of the time slider point A starts to move as a real tennis ball, so a student can see what really happens. Simultaneously i tis possible to stop simulation when a ball hits the ground, so student can read time of fall. (see Fig.7)

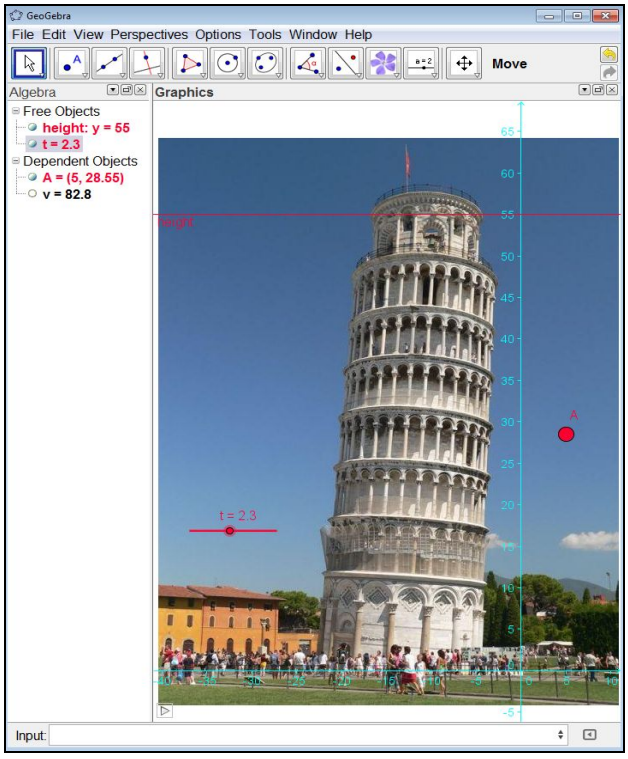


Fig.7 Virtual reality simulation in Geogebra

In connection with fall from Pisa Tower students can develop kinematical model $y = 55.86\text{-}5t^2$ from more fundamental physical laws and knowledge.

Particularly Galileo's free-fall law, an immediate and direct conclusion of fundamental Newton's second law: *Each falling object with shape and density allowing neglecting air resistance falls with acceleration 9.81 m/s*^{2}. It means that every seconds speed of the object increases its value by 9,81 m/s. The geometrical interpretation of the law is a half-line or ray running through points [0 s,0 m/s] and [1 s, 9.81 m/s].

Since the second fundamental kinematical knowledge says that the distance travelled by any object is represented by the area under a speed-time graph, powerful geometrical tools of Geogebra allows a very quick construction of corresponding area which can be interactively changed by simple dragging of a point lying on the speed-time graph. Exploring properties of the dynamically changing area, students are able to find required mathematical models describing changing speed and changing distance over time.

The second illustration shows a Geogebra application in electricity and magnetism. The fundamental law describing interaction between charges is Coulomb's law and fundamental concept describing electric field is vector of electric field or vector of electric force.

Its visualization is very important for students in correct understanding Coulomb's law as a physical model. Since physics education research shows that students have strong misconceptions due to lack of a clear and careful electric-field-vector operational definition in their minds, using this digital technology we give our student the opportunity to develop the required careful operational definition, where each step in Geogebra mimics perfectly every operation (action) needed in finding vectors of electric force or field.

Figure 8 is illustration of particular example where in Geogebra construction view student can see every operation corresponding to any displayed step in geometrical (graphics) window.

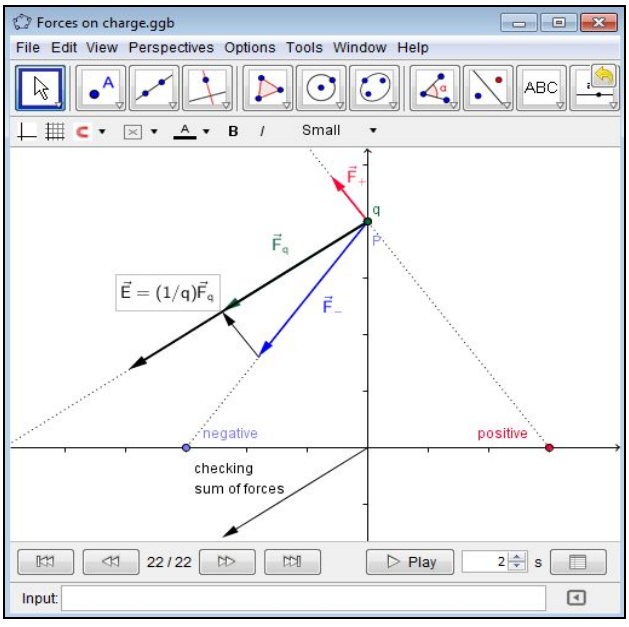


Fig.8 Geogebra Application in electricity and magnetism.

Our experience conclude than any phase of modeling as key science skill: visualizing, applying modifying or creating can be developed in Geogebra.

ACKNOWLEDGEMENTS

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REFERENCES

[1] J. Fulier, V. Ďuriš, P. Frantová, CAS vo vyučovaní matematiky. Univerzita Konštantína Filozofa, Nitra, 2007.

[2] M. Hančová, S. Lukáč, J. Sekerák and I. Semanišinová, "Active learning in mathematics using ICT", 8th International Conference on Emerging eLearning Technologies and Applications, 2010, pp.417–422.

[3] Geogebra – Free mathematics software for learning and teaching, http://www.geogebra.org/, accessed 2011 August

[4] Hohenwarter J, Hohenwarter M, Lavicza Z (2009) Introducing Dynamic Mathematics Software to Secondary School Teachers: The Case of GeoGebra, Journal of Computers in Mathematics and Science Teaching, 28(2), 135-146

[5] Betcher, Ch. and Lee, M.: The Interactive Whiteboard Revolution: Teaching With Iwbs, Acer Prees, Camberwell, 2009, ISBN 0-864-31817-0

[6] Redish, E.F. Teaching Physics with the Physics, Wiley, New York, 2003

[7] Ancsin G, Hohenwarter M and Kovacs Z (2011) GeoGebra goes Mobile, The Electronic Journal of Mathematics and Technology, 5 (2), https://php.radford.edu/~ejmt/, accessed 2011 August

[8] J. Hanč, M. Kireš and D. Šveda "*The digital literacy and key competencies as the cornerstones of primary and secondary education modernization"*, 8th International Conference on Emerging eLearning Technologies and Applications, 2010, pp. 429–432.

[9] S. Lukáč et al. "Využitie informačných a komunikačných technológií v predmete Matematika pre stredné školy", elfa, Košice, 2010.

[10] M. Čihák, "MUPAD aneb zdatný matematik ve vašem počítači", *Matematika, fyzika, informatika.*, vol. 12, pp. 110–118, October 2002.

[11] J. Hátle, "Matematika na internetu", *Matematika, fyzika, informatika.*, vol. 18, pp. 109–114, October 2008.

Testing Concept Maps Electronically

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Abstract— Paper deals with using of concept maps in testing knowledge. Concept maps are widely used in education and business because of they aid meaningful learning, help to organize, preserve and summarize knowledge and empower creativity. One can constructe own concept map by many software electronically. But concept maps can serve as qualitative and quantitative means for testing knowledge. Common used methods of testing knowledge are one-dimensional, give relative order in class or percentage rate of accuracy, and cannot give the relations between concepts and hierarchical structure of concepts. Special software was developed and used in testing fuzzy cognitive maps that make possible modelling inner causal relations of concepts in areas or systems changing in time. Results of testing knowledge will be given.

I. INTRODUCTION

Pupils' knowledge and skills are proved by different tests. Common used methods of testing are one dimensional. Results of testing give relative pupil's order in class or percentage rate of accuracy. These results cannot give the relations between pupil's concept and hierarchical sructure of pupil's concepts.

Pupil understands or misunderstands a subject matter. There are many pupils that misunderstand mathematics or science as follows from international testing PISA, TIMMS, etc. Solved problem is searching where is causal this misunderatndig in pupil's thinking. Answer can give the theory concept maps.

II. CONCEPT MAP

A concept map is a diagram showing the relationships among concepts. Concept map is graphical tools for organizing and representing knowledge [1]. Concept maps were developed in 1972 the course of Novak's research program at Cornell University where he sought to follow and understand changes in children's knowledge of science [2]. During the course of this study the researches interviewed many children, and they found it difficult to identify specific changes in the children's understanding of science concepts by examination of inteview transcripts. This program was based on learning psychology od David Ausubel [3], [4]. The fundamental idea in Ausubel's cognitive psychology is that learning takes place by *assimilation* of new concepts and propositions into existing concept and propositional framework held by learner. This knowledge structure as held by a learner is also referred to as the indivudual's *cognitive structure*. Out of the necessity to find a better way to represent children's conceptual undrstanding emerged the idea of representing children's knowledge in the form of a concept map. Thus was born a new tool not only for use in research, but also for many other uses.

The first textbook on this theme "Learning how to learn" [5] was published in 1984 by Joseph D. Novak and D. Bob Gowin. Joseph D. Novak has Slovak origin, grandparents were born near Bratislava.

Concept maps were developed to enhance meaningful learning in sciences. Construction of concept map includes concepts that are usually enclosed in circles or boxes of some type, and relationships between concepts indicated by connecting line linking two concepts. Words on the line, reffered to as as linking words or linking phrases, specify the relationship between these two concepts.

Concept is defined as a *perceived regularity in events or objects, or records of events or objects, designated by a label*. The label for the most concepts is a word, although sometimes we use symbols such as + or %, and sometimes more than one word is used.

Propositions are statements about some object or event in universe, either naturally occuring or constructed. Propositions contain two or more concepts connected using linking words or phrases to form a meaningful statement. Sometimes these are called semantic units, or units for meaning. . Figure 1 shows an example a concept map that describes the structures of concept maps an illustrateds the above characteristics.

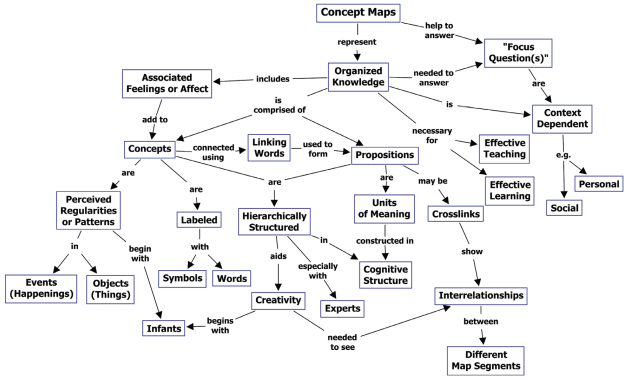

Figure 1 .A concept map showing the features of concept maps (according [1], page 2).

The concept maps are represented in a hierarchical fashion with the most inclusive, most general concepts at the top of the map and the more specific, less general concepts arranged hierarchically below. The hierarchical structure for a particular domain of knowledge depends on the context in which that knowledge is being applied or considered. It is the best to construct concept maps with

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reference to some particular question we seek to answer, which we have called a *focus question*. The concept map may pertain to some situation or event that we are trying to understand through the organization of knowledge in the form of a concept map, thus providing the context for the concept map. Applying a simple graphical convention consisting of hierarchical spatial configuration sets of nodes (concepts) and labelled links between nodes, concept mapping represents the logical structure of a subject matter.

Another characteristic of concept maps is the inclusion of *cross-links* that are relationships or links between concepts in different segments or domains of the concept map. Cross-links help to see how a concept in one domain of knowledge represented on the map is related to a conception another domain shown on the map. Cross-links often represent creative leaps on the part of knowledge producer in the creation of new knowledge. Concept maps can facilitate creative thinking by the hierarchical structure that is represented in a good map and the ability to search for characterize new cross-links.

New knowledge creation is a constructive process involving both our knowledge and our emotions or the drive to create new meanings and new ways to represent these meanings. Learners struggling to create good concept maps are themselves engaged in a creative process, and this can be challenging, especially to learners who have spent more of their life learning by rote.

III. Concept map construction

A person constructing the concept map has to be very *familiar with a domain* of knowledge concept map. A good way to define the context for a concept map is to construct a *focus question*, that is, a question that clearly specifies the problem or issue the concept map should help to resolve. Every concept map responds to a focus question, and a good focus question can lead to a much richer concept map.

The next step is to identify the *key concepts* that apply to this domain. Usually 15 to 25 concepts will sufficent. These concepts could be listed from the most general at the top and to the most specific at the bottom of list. This list of concept is called a *parking lot*, and is only aproximate. Some concepts may remain in the parking lot as the map is completed if the map marker sees no good connection for these with other concepts in the concept map.

The next step is to construct a preliminary concept map. This can be done writing all of the concepts on sheet of paper or elecronically using computer software program such as IHMC CmapTools [6]. Computer software programs are better in that they allow moving of concepts together with linking statemensts and the moving of groups of concepts and links to restructure the map. When CmapTools is used in conjunction with a computer projector or two or more pupils can easily collaborate in building a concept map and see changes as they progress in their work. A concept map is never finished. After preliminary concept map is constructed, it is always necessary to revise this map and the other concepts can be added. Good concept map usually result from theree to many revissions. This is one reason why using computer softwae is helpful.

Students often comment that it is hard to add linking words on the “lines”of their concept map. This is because of they poorly understand the relationship between the concepts, or the meaning of the concepts and it is the linking words that specify this relationship.

Computer-Based Concept Mapping uses software for construction of concept maps. This software is as follows in alphabetical order: Activity Map, Decision Explorer, Diagrammer, Inspiration, Kidspiration, Mind Genius for Education, Mind Manager, Mind Mapper, SemNet, Star Think. There are two conception of software. The first coception has structured approach. User must define format of pripering map beforehand and determine shape of flowchart. No-structured approach gives to user freedom for construction of proper format.

IV. Evaluation and concept maps

New science texbooks include of concept maping as one way to summarize understandings acquired by pupils after they study a unit or chapter. Change in school practices is always slow, but it is likely that the use of concept maps in school instruction will increase substantially in the next decade or two.

When concept maps are used in instruction, they can also be used for evaluation. Now multiple choice tests are used from grade school through university. May be that concept mapping will be used in national examinations as a powerful evaluation tool.

Structure of knowledge is considered as important element of pupil’s understanding. Structure of knowledge successful pupils has elaborate and integral structure bounded concepts that facilitate problem solving and the other cognitive activities of pupils.

Structure of knowledge can be thought to be important but no-measurable component of pupil’s results. Technic of concept maps can represent the structure of pupil’s knowledge and can be means for investigation of concept knowledge structure. Pupil promotes his own private view of concepts and relationships between them on concept map. Thus he vizualizes results of his learning, his preconceptions, conceptions and misconceptions. Misconception is a mistaken thought, idea or notion, false understanding of concept. Misconception is a wrong structure that has to be overcome by pupils with support of teacher.

V. Evaluation of concept maps

Pupil can evaluate his ir her concept map by comparison with concept map in instruction and this way eveluate his or her level of understanding of subject matter.

People who used *unified scoring method* are trained to test every concept map and the pupils’understanding of the conccept that he or she stated in his or her map. According to this evaluation, every map is eveluated with a measurement between 1 and 10 (McClure and Bell, 1990).

The *interrelated scoring system* was adopted from a method which was improved by McClure and Bell (1990). In this method, individual maps composed from independent propositions which were defined in the map, were scored. A proposition is defined as a relationship between concepts, a connection of two concepts

highlighted with connection line. Every proposition was scored between 1 and 3 according to a scoring protocol accepted the proposition as true.

Structural scoring model was adopted from a method which was defined by Novak and Gowin [5]. According to this model, scoring concept maps are made as follows: for each proposition 1 point, for every hierarchical proposition 5 points, for every diagonal connection 10 points, for every example 1 point will be given.

Another model is given as follows: for correct proposition between two concepts 1 point, for every hierarchical proposition 1 point (the last two level arenot take into account), branching – to the first branching 1 point, to the next branching 3 points, correct label between two concepts 1 point.

VI. TESTING CONCEPT MAPS ELECTRONICALLY

Concept maps are valuable diagnostic tool. This tool was used in testing concept maps electronically. Types of test items were as follows: shape of concept map was given, yellow concept was given and the others were given as propositions for pupils, see examples Fig. 2 and Fig. 3.

Goal of test item in Fig. 2 is deper understanding divisibility. Mistakes in solving the concept map give misunderstudings or misconceptions of pupils. These start new way of teaching/learning process.

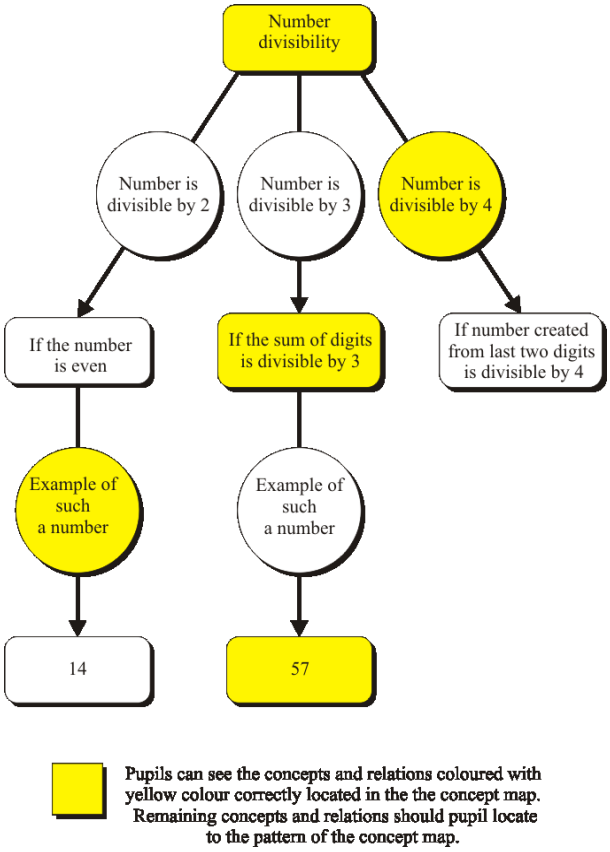

Figure 2. A concept map on divisibility

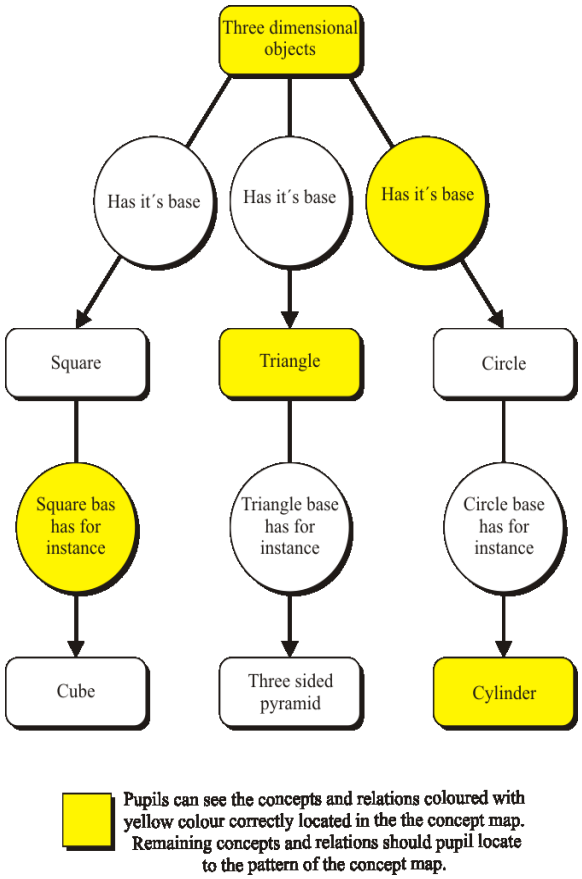

Figure 3. A concept map on three-dimensional objects

Goal of test item in Fig. 3 is deper understanding three-dimensional objects. Pupils have three-dimensional vision very low. Mistakes in solving the concept map give misunderstudings or misconceptions of pupils. These start new way of teaching/learning process with real three-dimensional objects.

Testing was carried out at secondary schools in the Moravian-Silesian Region in September 2011. Total number of pupils was about one hundred. Special programe was developed for this testing and evaluation of testing.

VII. CONCLUSIONS

Concept maps are very useful learning and diagnostic tool as concern understanding of subject matter by pupils and knowing teachers how to facilitate. The construction of concept map penetrates to teaching/learning process in the Czech schools [7].

There is much software on web and some teachers only start using this software. Out of spite this situation, the testing concept maps electronically was carried out and teachers were forced to think about. The data of testing are analyzed for further using in teaching/learning process.

REFERENCES

[1] J. D. Novak, and J. Canas, *"The Theory Underlying Concept Maps and How to Construct and Use Them,"* Technical Report IHMC CmapTools 2006-01 Rev 01-2008, Florida, Institut for Human and Machine Cognition, 2008.

[2] J. D. Novak, and D. Musonda, "A twelve-year longitudinal study of science concept learning," *American Educational Research Journal,* 28 (1), 117-153.

[3] D. P. Ausubel, *The psychology of meaning verbal learning*. New York: Grune and Stratton, 1963.

[4] D. P. Ausubel, *Educational psychology*: A cognitive view. New York: Holt, Rinehart, Wiston, 1968.

[5] J. D. Novak, and D. Bob Govin, "*Learning how to learn"*, Cambridge: Cambridge university press, 1984.

[6] A.J. Canas, et al. "CmapTools: A knowledge modeling and sharing environment." In A. J. Canas, J. D. Novak, and M. Gonzáles (Eds.). *Concept maps: Theory, methodology, technology.* Proceedings of the first international conference on concept mapping (Vol I., pp. 125-133). Pamplona: Universidad Públice de Navara, 2004.

[7] J. Mareš. "E-learning, který využívá k učení objektivní I subjektivní mapy pojmů", *Information and Communication Technology in Education*. Ostrava: Repronis, 2010, pp. 17-33.

Innovative learning stories for teachers based on latest IT technologies

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***Abstract*— This paper deals with new ways of teaching and learning with major support of new technologies and software solutions in primary and secondary schools. Children are keen to use new technology, mobile devices, and internet applications. They use it more for out of school activities. School has to explore the potential of new technologies and offer curricula in attractive way. Connection between traditional and on-line content should be found, linking existing educational objects into IP world is necessary. Teachers are facing new challenges how to teach in a new setting different generation of pupils. This paper brings review of some tools and presents selected learning scenarios which should help to do so. Paper also presents project iTEC funded by European Commission which helps to solve some of the problems that teachers are facing. The research project wants to identify trends for future classroom, recognize best practices and test them in 1000 classrooms throughout the Europe.**

I. INTRODUCTION

Fast development in field of computers, networking and mobile technologies has already begun to transform the way how schools teach and learn. ICT is no longer fear for some teachers and they do understand the need to implement at least some software and hardware gadgets into teaching. For example social networks could offer excellent tools for communication and content sharing. Latest mobile phones and tablet PCs offers high computing power which enables delivery of the multimedia content like videos in HD. Search engines allow finding answer on many questions in seconds. Libraries in schools do scan and recognize text in books into on-line databases as reading and searching in traditional way seems to be very obsolete for pupils.

These changes require to identify and select proper scenarios for teaching and to select right tools in order to improve educational process. Question how to attract pupils to study and to prepare them well for life is worldwide issue. Leaders in field of education across European countries have recognized the real need for change in curriculum with the development of ICT. There is a broad wish to extend and exploit the potential for knowledge dissemination, more effective learning and the development of efficient education services in support of reform goals at affordable cost. Some proponents argue that reforms using ICT are intended to ensure equal access to educational opportunities and quality education appears in many ways to be dependent on the effective deployment of ICT.

Areas where change is needed in order to achieve a transformation of education include goals and objectives, content and its sources, evaluation and assessment, structure of learning activities and interaction between participants. Also there is need to redefine job descriptions and working habits and awareness of parents and society.

ICT has the potential to create new, open learning environments, play an instrumental role in shifting the emphasis from a teacher-centered to a collaborative, learner-centered environment. The real need is to enhance the role of students from passively receiving information to being actively involved in their own learning. This evolvement should help to address new roles which teachers need to play in preparing students for an emerging knowledge-based and technology-driven society. ICT could also support long-distance exchange and interaction between geographically spread groups of teachers and their students.

II. EU PROJECTS FOR EDUCATION EVOLVEMENT

During last few years European Union has funded and presented a lot of projects in the field of primary and secondary education. Authors had an opportunity to be involved into two very interesting ones which are shortly presented below.

A. Project eMapps.com

First project named eMapps.com (Motivating Active Participation of Primary Schoolchildren in Digital Online Technologies for Creative Opportunities through Multimedia) brought idea of gaming into schools and created real application [1].

The main objectives of eMapps.com were to build communities of creative, networking children in the New EU Member States (NMS), generating their own cultural content and communicating with peer groups in other countries and to contribute to the growth of a community of teachers who are aware of the potential for change through 'schools without walls' and who exchange knowledge and experience through communication with counterparts in other NMS countries.

Project has developed adaptable interactive tool (primarily games played on a mobile platform) with which delivered learning objectives and which helped to integrate the use of ICT in the delivery of the school curriculum. Project also targeted goal to establish processes and facilities for teachers and children to access relevant digital content available through a variety of sources while playing the eMapps.com games - and to

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make the multilingual and multicultural local content created during the games suitable for sharing and repurposing for use in the wider eLearning context of schools and children in NMS.

One of the most interesting ideas of the eMapps.com project was to create a child's living map of Europe, based on geography, history and heritage, accessible through mobile devices, which can be continuously expanded as an important and rich content resource for schools in NMS and elsewhere [1].

B. Project iTEC

iTEC (Innovative Technologies for an Engaging Classroom) is a four year, large-scale project that takes an informed look at the potential classroom of the future. The key aim is to develop engaging stories for learning in the future classroom that can be validated in a large-scale pilot and be subsequently taken to scale [2].

Starting in September 2010, iTEC will bring together policy makers, researchers, technology suppliers, other technology-enhanced learning experts and innovative teachers in order to design and build scalable learning and teaching stories for the future classroom with recognition of the realities of pace of the educational reform process. Rigorous testing of these future classroom scenarios in large-scale pilots will then be carried out in order to significantly increase the possibility that innovation can be mainstreamed and taken to scale when the project ends.

iTEC, therefore, will explore a vision of the future where schools will remain the key location for learning and assessment as part of a wider network of physical and virtual learning locations. In doing so, the project recognises that the learning process will increasingly engage with other stakeholders including parents and cultural and business sector members and draw in adult and informal learning. iTEC also begins with a clear understanding that the starting point for change is current teaching practice and that educational policy making in the real world must be understood as the context for this change. The project will not only examine how innovative technologies can be deployed but also the underlying change processes that are required in order for innovative teaching and learning practices to be mainstreamed and taken to scale.

iTEC objectives are [2]:

1. To develop and refine a range of teaching and learning stories that include new approaches to assessment, (developed by project partners and teachers themselves) for the future classroom in order to engage teachers and pupils together with other stakeholders contributing to pupils' learning and growth.
2. To develop decision support criteria (technological, pedagogical and policy-related) that facilitates the selection of stories that can be mainstreamed and taken to scale.
3. To develop specific teaching and learning activities, also involving new approaches to assessment, based on the scenarios and test these in a pre-pilot phase with a focus group of teachers, with a view to determining which of these have the potential to be mainstreamed in a number of countries.
4. To carry out large-scale pilots in up to 1,000 classrooms in at least 12 countries exploring both the integration of technologies and how these impact on teaching and learning practices and the engagement of a wider group of stakeholders outside the school.
5. To research the skills and competences needed by teachers in the classroom of the future and to equip teachers and ICT co-ordinators, both within and beyond the project, with the pedagogical knowledge and skills needed to implement project stories.
6. To evaluate the extent to which the iTEC stories have been successful in supporting collaboration, individualisation, creativity and expressiveness and identify those with maximum potential to have a transformative effect on the design of the future classroom. Also to identify the underlying change processes necessary to bring about this transformation.
7. To widely disseminate project results and ensure they can be taken to scale by implementing a mainstreaming strategy that includes the formation of a new high-level body at European level to ensure that iTEC stories and work in the large-scale pilots contribute to the educational reform process.

III. PROJECT ITEC LEARNING STORIES

Project iTEC consortium partners under the leadership of European Schoolnet (consortium of Ministries of Education) have created several stories [3] how education should be modified in order to implement new technology and techniques into classes. Three of nine created scenarios for the first project cycle were presented to teachers in Slovakia in order to gather feedback and to evaluate feasibility in such scenario implementation. Full texts of these three scenarios will now follow. All the stories were distributed by the partners and tested in their countries.

A. Recognizing Informal Learning

Students document and reflect on their informal learning that occurs outside of school. They upload this onto a portfolio and share their learning with teachers and parents where appropriate.

Ms Fierro recognises that Paulo, like several of the students in the class, does a lot of work outside of school but is less interested in the formal curriculum. As a result the school has created a space for students to share their out-of-school experiences as part of their formal school curriculum, which offers students the opportunity to get formal credits for their out-of-school activities where appropriate. Paulo collects and documents evidence about the skills and knowledge he gains when involved with his hobby, skateboarding. He places all the evidence he collects onto his online portfolio. This is provided by the school, but accessible from anywhere that has an internet connection. He collects evidence in a range of formats including scans of the designs he has created for skate logos and skate clothing, photos of the different stages of him building a ramp, and a video of other skaters using his ramp at a competition. He captures this evidence using a range of different tools, including his mobile camera, a

friend's video camera, uploaded computer created designs, and paper drawings which he has scanned in at school.

Figure 1. Recognizing Informal Learning Story

Once a term Paulo and the rest of the school have the opportunity to present their collected evidence at a 'show and tell' gallery that happens in school. Paulo can also present his work to an individual teacher if he feels uncomfortable sharing it with a wider audience, but he is happy to share it with other students. Teachers from different subject areas view the students' work and decide if they can use the evidence to support formal assessment. Ms Fierro teaches design and technology and decides that she can use Paulo's evidence to support his accreditation in this subject, particularly in the areas of 'use of materials and their construction'.

Paulo's online portfolio has a 'school' and 'public' setting which means he is able to share selected parts of his work with anyone in the school, or with a wider audience. He is asked if he wants to share his work with his parents using the share settings on his portfolio but he declines.

B. Reacting to Student Feedback

Building on the range of digital resources that already exist, teachers have access to a Learning Management System (LMS) in which students can record responses based on understanding and progress using a student response system. With this information they can adapt their teaching style appropriately.

As a newly qualified teacher, Mr Kowalski uses a range of digital resources to increase the amount and quality of support he gives to his learners so to provide more tailored formative responses to his students' progress. Mr Kowalski is encouraged to investigate his students' understanding by monitoring their progress through an interactive response system which is used throughout the school. Mr Kowalski asks a mixture of open and closed questions throughout the lesson, and depending upon the student's responses (which are returned as a mixture of numerical votes and free text responses,) he changes his pedagogic approach to make sure he revisits areas that students are challenged by and quickly builds upon areas where they have good understanding. Seeing two students respond with detailed written responses, he asks them to sit with four students who struggled with a previous question to act as peer mentors, whilst he revisits some work with another group of students.

The student response system is linked to the school's LMS which ties student's responses to other data, giving Mr Kowalski and other teachers a better insight into students' progress and development. By using this more detailed understanding of his students, Mr Kowalski alters the students' groups and the activities he sets them.

In order to provide greater structure for his students' learning, Mr Kowalski uses this more detailed understanding of his students' interest and knowledge and accesses an education 'app store' to find appropriate resources for different students. Accessing the 'app store' from his laptop, Mr Kowalski adds specific resources to the names of different students that he thinks will benefit from a particular resource. By doing this, specific resources are linked to a 'graduated lesson plan' that

Figure 2. Reacting to Student Feedback Story

allows his students to access further resources, linked to their progress and concerns, which are captured by the interactive response system. The four students who were struggling with some key concepts have access to a video of an older learner explaining a key issue, whilst two students who demonstrated a good understanding access a set of challenges that ask them to plan an applied project.

Mr Kowalski continues to monitor the students' work through the LMS, the interactive response system and by talking with students as they continue with their work. Towards the end of the lesson, Mr Kowalski asks each group to rate the resources that they have used which add to the overall ratings of each resource in the 'app store'. By observing these ratings and by using all of the monitoring opportunities available, Mr Kowalski develops a deeper insight into the progress of each student, which informs his use of the graduated lesson plan for future lessons.

C. Outdoor Study Projects

The students go out to explore the school grounds tasked with a problem or challenge. They have to either capture authentic data, or explore how concepts can be applied in the real world.

Ms. Rossi, a science teacher, has been liaising with the geography teacher and they have noticed that their students need to develop a more in depth understanding of the local natural environment and wildlife. Ms. Rossi has also noticed that although her class works well as individuals, they would benefit from more group learning. She decides to get the group to work collaboratively on a problem based activity to do with nature and the local environment. When deciding on a specific activity for the class she liaises with the geography teacher to ensure the chosen activity could also support learning in geography. She sets her class the challenge of finding out why the population of ladybirds has decreased in the school grounds over the last year.

Carmen, a student, goes outside with her group to collect real data to help the class's investigation. Each group member has a different role and a different instrument to capture authentic data. Carmen uses her mobile phone to capture images of the areas where most ladybirds live, whilst others in the group record the temperature and survey habitats. Ms. Rossi lets the students work together in groups so she can take the role of observer and coach. This helps her understand what skills the students need to practice. She notes down what skills the students need to develop to help her design future learning activities. She realizes the group need more training on using instruments without disturbing wildlife, and also how to set specific group goals.

After gathering a series of photos Carmen comes back to class with her group and they share their data and findings with each other. They get some specific support from Ms Rossi on how to use a software package to draw conclusions from the group's numerical data. Having drawn their conclusions, the group choose to create a short film from their photos and data to share their findings with other students in the class. They work together using laptops and a web tool to create a short digital film explaining what they found. Carmen and another student upload their photos while the rest of the group writes a script to present their findings. They each record a part of the presentation script and use the automatic editing software on the web tool to create the film. This film is posted on the school's learning platform for the class to view for homework, and also for students in a geography class, who are doing similar work, to comment on. The group also decides to post it on the public area of the learning platform so they can show their parents/carers when they get home.

Figure 3. Outdoor Study Projects Scenario

IV. First Cycle Feedbacks Collected in Slovakia

Presented three stories were evaluated by two experienced teachers at Secondary grammar school in Spisska Nova Ves, Slovakia. School was selected randomly, feedback does not represent general idea in Slovakia but teachers provided very valuable comments. Some notes based on face-to-face meeting is presented below.

A. Recognizing Informal Learning

Presented story was very attractive for teachers and following comments were collected:

- selection of the presented activity should be consulted with teacher first,
- some definitions of what is expected are needed, sure creativity is required from student mostly
- motivation (marks) to do the task should be interesting for them,
- online portfolio for such sharing is missing at the school, but any internet platform should be accepted,
- some older teachers (in general) probably will not accept such way of presentation due to their lack of modern technology skills,
- although this story is targeting students who do not like formal learning, teachers expect that the most active ones will be medium and better students,
- teacher will need to find the key how to encourage shame students to present their out of school activities,
- motivation is that students are encouraged to use technology they like – teacher will see how they are able to present it using "their generation" language/technology,
- both teachers see the problem also in sharing students outputs with other teachers at the school – how to motivate other teachers to find time for seeing the portfolio if many students attend such a presentation,
- subjective marking scheme – if teacher does not like the presented activity (e.g. graphitti) marking could be a problem (presented subject could hide the work of the student),
- for some teachers it could be motivating to participate in such way of teaching – not only because some of the student activities are interesting, but also they will see many new technologies at work,
- presentation of activities which are close to presenters (students) should help to evolve presentations skills – e.g. not focused on what to present, but how to present it in an attractive way.

B. Reacting to Student Feedback

Presented story was welcomed by teachers (probably it is more attractive for teachers than for students) and following comments were collected:

- Learning Management Systems as tools are very welcomed by teachers and they see them as great tools not only for students but also for themself,
- problem that was presented by teachers immediately after reading the story could be summarized as "missing LMS installation in school" and "missing administrator" for such tool – rest of the discussion is presenting story as we have such tool and unlimited sources for usage of that tool,
- LMS will be probably attractive only for good/active students. We were not able to find motivation factor for "lazy" students to "wake up" and use offered source of content for study (even from Application store),
- Feedback from students – great! For teacher who is interested in quality of offered curricula this will definitively help. But it will require a lot of time to spend with feedbacks and with finding of attractive and user-adapted learning sources.
- Time is the weakest point in this story. Teachers like when provided "tools" save their time. Here it will need a lot of time resources in the adaptation phase, but later it will be great storage of learning objects.
- The software solution for voting should be the only possible way for feedbacks. There are insufficient funds for such hardware solutions at most of the schools in Slovakia.
- Due to the school reform (which is in progress recently) in Slovakia some subjects do miss officially approved books – LMS with digital content should be great for students in meantime.
- App store – great idea! We miss such a repository in Slovakia. No matter if content will be for free or not – learning objects are difficult to find for many teachers. What about of exchange of student created learning materials by students? Motivation?

C. Outdoor Study Projects

Last presented story teachers commented as great idea with high potential to be interesting for students. But there were some comments presented:

- How big the groups should be? If small – good for the results, good for the involvement of every member. But more teachers have to go out with the group during activity (given by law) – missing teachers.
- Typical school hour has only 45 minutes in Slovakia – too short time period to go out and do something.
- Teachers are skeptical that this can be done during normal subject hours – a lot of formal learning has to be done during normal classes – it is defined by national curriculum plan. This activity should be only as part of after school activities.
- Students for sure will like such learning – it is new for them, they're out of class, they can work with technology.
- Outdoor activities will be limited only to school surrounding – more teachers are required to monitor children at given type of lessons.
- School needs to buy some technology (video cameras, cameras, microphones, GPS, sensors ...) in order to implement this story. Multiple same type devices are needed – problem for many primary schools.
- If multiple groups are outside for an outdoor activity – every group should have a different task. To work on the same topic is demotivating for the groups.
- Overall feeling from story is very good, but implementation is possible only as part of after school activities.

V. Software Tools Available for Teachers

Important part for implementation of new teaching practices is to have proper tools in hands. In our case it is software for communication, sharing, presentation, evaluation and marking. Many applications already exist but still most of the teachers are not familiar how to use them in teaching. Following part of this article will shortly present just few of them as for inspiration.

A. Web Applications

There are a lot of web services available on market providing content sharing and collaboration. The most known services are provided by Google, Microsoft or large software players. For example, Google during last years presented many interesting web-based applications like Google Docs for creating, editing and sharing of various documents for public or defined group. Also collaboration and versioning is helpful for students with same tasks, creating common document. Google Sites allows simple creation of webpages for schools projects, wikis for bigger content libraries. No matter how information are analyzed by Google, for teacher usage of this tools help to collaborate with student groups using simple user interface and wide sharing capabilities. Most of the applications are available as free service.

B. Learning Management Systems / Course Management Systems

As teaching is complex process it involves also content sharing, testing and marking. For this reason Learning Management Systems (LMS) and Course Management Systems (CMS) were developed. One of the well-known CMS/LMS is Moodle [4]. Moodle has several features considered typical of an e-learning platform. Some typical features of Moodle are [5]:

- Assignment submission,
- Discussion forum,
- Files download,
- Marking,
- Moodle instant messages,
- Online calendar,

- Online news and announcement (College and course level),
- Online quiz,
- Wiki.

Some other well-known LMS/CMS are Chamilo, Haiku, ILIAS, Blackboard, Open LMS, etc. Most of these solutions are available as freeware.

C. Testing tools

One of the most time consuming tasks for teacher is verification of real student knowledge and skills. Recently market offers wide variety of tools for testing which allows to test student in real time and to show final score. Moodle could do this task, almost every LMS/CMS. But these systems do not offer generation of new tasks based on pre-defined mathematic formulas and are not able to display personalized recommended step by step solution. This is solved by application named GENEXIS [6]. It provides functionality to create, update and spread the latest educational content developed by the governmental services through Internet. It allows creating unlimited amount of training options on any subject as well as gives opportunity to monitor student's progress throughout the study process.

Major difference between GENEXIS and other systems as Moodle is content editor that allows teachers to create exercise templates. Based on these templates GENEXIS generates multiple variations of one exercise. This way each student can receive an individual exercise for homework or test or else can train on one exercise template several times as new exercise variation is generated each time. When student completes the task system evaluates the result and shows the solution process enabling student to "learn-by-doing". GENEXIS in licensed on per-school license [7].

D. Social Networks

Services like Twitter and Facebook completely changed life of millions of people all around the world. Sharing instantly what is on my mind to tens of hundred several times a day from everywhere using even mobile devices made a small revolution in life of pupils. These services have potential to be used also for educational purposes. It requires that teacher will prepare interesting tasks for pupils together with methodology aiming educational goals of given subject.

CONCLUSION

This paper presents some ideas related to share best practices of teachers with application of the new information technology developments. Several EU funded projects in last years were trying to define new methods and methodology which will lead to better educated young generation. As society and customs are changing school needs to be flexible to reflect it in proper way. Three presented stories are result of EU project iTEC which is now in its first phase.

Paper also presents some comments of teachers who are skilled and have years of experience in Slovak educational system. These teachers believe that in future more and more learning will occur outside traditional class rooms. Some schools are moving online to 'virtual school', building on-line community of students, staff and parents. Everything is possible thanks to simple access to Internet at home or at work. Due to this fact students can work on projects either from school or home, can be creative, communicative and innovative. It is important to foresee future ways with support of the latest hardware and software solutions.

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REFERENCES

[1] R. Krizova. (2008, Oct. 17), *eMapps Games project website* [Online]. Available: http://emapps.info

[2] iTEC consortium. (2009, Jan. 10) *iTEC project website* [Online]. Available: http://itec.eun.org

[3] iTEC consortium. (2010, Oct. 15), *iTEC project website - Scenarios* [Online]. Available: http://itec.eun.org/web/guest/scenarios

[4] Moodle. (2011, June 22), *Moodle community* [Online]. Available: http://www.moodle.org

[5] Wikipedia. (2011, Sept. 10), *Wikipedia : Moodle* [Online]. Available: http://en.wikipedia.org/wiki/Moodle

[6] DataPro Grupa. (2011, Sept. 22), *GENEXIS Desktop* [Online]. Available: http://www.genexiseducation.com/GenExisDesktop/

[7] M. Michalko and F. Jakab, "Pilot implementation of GenExis testing system in Slovakia," in *7th Int. Conference on Emerging eLearning Technologies and Applications, ICETA 2009 – Conf. Proc*, Stara Lesna, 2010, pp. 227-230

MACHS: an authoring tool to create serious games for machine-tool operator training

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***Abstract*—In this paper, we present the project MACHS, a platform for the generation of serious games, i.e. courses in 3D environments for machine-tool training. The platform consists of two applications: an easy-to-use authoring tool for editing the courses and a 3D simulator for running them. In this paper, we describe the features and the functionalities of each part of the platform. We also describe the structure of the XML files designed for the storage of the information about courses, machines, cameras, interaction, etc. and how we use them to link the editor and the simulator.**

I. INTRODUCTION

Serious Games are generally defined as Computer Games that are not directly oriented to entertainment. The purpose of Serious Games is to use such playful aspect for educational, informative or communicative objectives.

According to experts from the European Center for Children's Products [1], Serious Games can be classified in five categories: Edutainment, Advergaming, Edumarket Games, Political Games and Training and Simulation Games.

While the first is focused on transmitting knowledge, the second uses Serious Games for marketing purposes. Edumarket games are a mixture of the first two types. Political Games' objective is to make aware of political and social topics. Finally, Trainning and Simulation Games immerse the user in an environment whose behaviour replicates a real environment's behaviour, in order the user to familiarize with it. The platform described in this paper was developed to create and run courses that can be classified in the last category.

In recent years, the number of applications in the field of Training Games has increased rapidly. Despite the fact that most of them are in experimental phase, there are some commercial applications that show that Serious Games could be very useful. 3Dsolve [2] and BreakAway [3], that uses Serious Games for military training or PIXELearning [4], that use Serious Games to train adults in business and finance, are some examples.

Most of the work done in the field of Training Games needs experts in two fields. An expert in computer games who develops the application and an expert in the subject to train, who designs the game logic. MACHS, the project presented in this paper, partly funded by Basque Government (IG-2009/0000607), pretends to eliminate the need of the expert in computer games or 3D animation.

The main idea of the project MACHS is that an expert in machine-tool manufacturing could create a course easily and without any help. For that, we developed an authoring tool called Course Editor and a simulator that runs the course designed by the user.

The paper starts with a brief overview of the state of the art in Serious Games in section II. Next, we describe the applications that compose the system MACHS in section III and define the XML files used for their correct running in section IV and V. Finally, we conclude the paper and describe future improvements in section VI and VII.

II. RELATED WORK

The success of the utilization of Serious Games is clear if we take into account the amount of fields they have been used in.

Health and Medicine are two of the fields where the Serious Games have been used most. Cabas et al. [5] developed an application or training emergency medical services nurses in decision making and Siqueira and Nunes [6] presented a Serious Game to train the users of medical Virtual Reality tools. Göbel et al. [7] introduced some health exergames using a combination of game technology and game-based methods and concepts (e.g. competitive multiplayer features), mechanisms for personalization and adaptation and sensor technology. Besides, it is remarkable that there are several companies [8, 9] dedicated to create Serious Games in this field.

Several projects use Serious Games for training skills in emergency situations. This kind of situation is not easy to reproduce in the real world, but it is in a 3D environment. Chittaro and Ranon [10] propose serious games as a tool to acquire personal fire safety skills and Haferkamp and Krämer [11] presented DREAD-ED, a technology-based teaching methodology for in crisis management units training. Linehan et al. [12] created a serious game designed to teach group decision making skills to coordinators of groups that respond to real-world emergencies such as floods, fires, volcanoes and chemical spills. The results showed that trained groups work better than the non-trained ones. This kind of projects and other different works [13, 14] show that Serious Games are helpful to improve the work in groups.

There are projects that work in really different fields, like management of National Parks for Biodiversity Conservation [15], cultural training [16, 17], language learning [18, 19] or military training [20].

There are some projects that are similar to ours or can be classified in the same field. Games2Train [21] is a

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shooter type game that aims to train students in the utilization of CAD 3D. The students are inserted in a story where they have to meet several milestones. For example, they have to design some pieces of the machine that will be used to defeat their enemy.

Rilling et al. [22] presented an interdisciplinary work on the application of computer game principles and techniques within an automation industry training scenario.

Rosendo et al. [23] developed a serious game for training of live line maintenance activities, i.e. activities without interrupting the flow of energy on the line. The platform uses devices such as the Nintendo Wii Remote and 3D TV sets to provide a novel model of interaction and navigation.

Regarding authoring tools, the work presented by Göbel et al. [7] contains an application based on [24]. Although it is similar to our Course Editor, the utilization of 3D animation and the machine-tool context make them different.

III. SYSTEM OVERVIEW

The system developed in the project MACHS contains two main applications. The first application is an authoring tool where an expert in machine-tool manufacturing can design a course for students that are learning how to use a machine or how to do its maintenance. The second application receives the output of the first one and runs a course in a 3D environment where the students must follow the steps designed by the expert. In what follows, we will denote these two applications Course Editor and 3D Simulator respectively. Furthermore, the students have two options in the 3D Simulator: they can run the simulation, where the system shows the correct steps automatically or they can do an exercise where they have to explore the 3D reproduction of a machine and try to take the correct steps to finish the course correctly. The system supervises the exercise and displays texts about the correctness of the user's performance.

A. Course Editor

As stated before, in this part, the teacher, the person that knows the machine and how it works, prepares a course about the control or the maintenance of the machine. The main goal of the Course Editor is its usability, so that an expert in machine-tool manufacturing but not necessarily initiated in 3D applications can generate a 3D course easily.

The user of this application can edit some general features that describe the course:

- Name: the name of the course will not appear in the 3D Simulator, but it identifies the course.
- Description of the simulation: the user defines the statement that will be showed during the simulation, i.e. the option that shows the correct steps.
- Description of the exercise: the user defines the statement that will be showed during the exercise.

The course is designed in the main diagram of the Course Editor (see figure 1). The diagram is composed by squares that are linked with arrows. Each item or square in the diagram represents a step that can be taken during the course and the arrows represent if it is allowed to concatenate these steps. The user of the editor has to define the name of the step, which piece has to be chosen and which action has to be done with it, e.g. the user defines the step "tighten screw 1" by choosing the "screw 1" in the module "carriage X" and the action "tighten". Moreover, the teacher can set the statement that will appear when this step is taken, e.g. "You tightened screw 1. This is a correct step".

All the items show the name of the action in order the teacher to catch the structure of the diagram, i.e. the course, in a quick look.

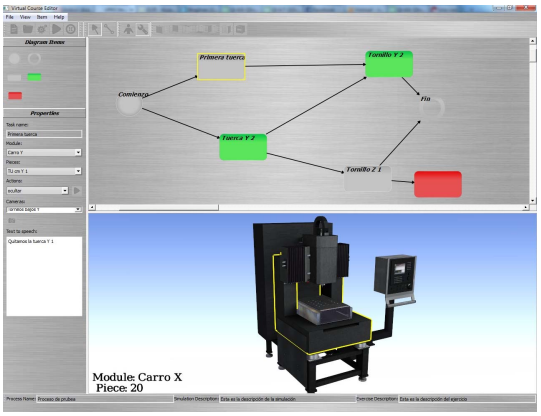

Figure 1. The diagram and the machine in the Course Editor

These are the different types of items that can be defined in the Course Editor:

- Initial and final steps: the user can define as many initial and final items as he wants in the diagram. These items are identical with the usual step items. However, the system will identify these steps and will not allow the student to start a course with a step not defined as an initial one and will notify the student that the course is satisfactorily finished when a final step is reached.
- Simulation steps: the teacher can define several paths that lead to a correct end in the diagram, but the 3D Simulator can show only one of those when the student asks the system to do so. Therefore, the teacher defines the path of steps that the 3D Simulator will show with these items. The editor ensures that the chosen path is unique. Simulation items are similar to the usual ones, but in this case, besides the usual steps' aspects, the user has to define the camera used to visualize this action. During the simulation in the 3D Simulator the system handles the camera automatically, so the camera for each step has to be defined in advance. Moreover, the user can isolate the simulation path, i.e. he can remove temporarily the items that are not in the simulation path in order to avoid confusion when designing the simulation.
- Incorrect steps: when the student is doing the exercise, if he doesn't choose an action that follows the last correct step he took, the system automatically tells him he is choosing an incorrect action. Nevertheless, the teacher can set special incorrect steps in the diagram. In these items the statement that will appear in the 3D Simulator is

very important, e.g. "You have just broken the machine".

In order to get a better usability, the editor shows a 3D reproduction of the machine that will be used in the 3D Simulator (see figure 1). The user can move the camera to see the pieces of the machine from any point of view or can use the predefined ones, i.e. the ones that can be chosen when running the 3D Simulator. This aspect is important, because the teacher has to decide which camera will be used during the simulation in the 3D Simulator.

The 3D reproduction of the machine can also be used for choosing the pieces. Instead of choosing the module and the piece in a menu, the teacher clicks the piece in the machine and the system automatically sets the details in the menu. The teacher also can visualize the animation that will be triggered in the 3D Simulator when this action is chosen.

In conclusion, with the overall view of the course showed by the diagram and the help of the 3D reproduction of the machine, the teacher can easily design the course for his students.

B. 3D Simulator

The 3D Simulator is the application that takes the output of the Course Editor and automatically generates the designed course in a 3D environment. The user of the 3D Simulator cannot change anything in it. He can only interact with the application.

Once the user, a student, opens the application, a menu shows two options. The user can ask the system to show the correct steps he has to take to finish the exercise or he can directly try to do the exercise. At any time, the user can return to the main menu and change the mode.

In the first case of the main menu, the system shows all the simulation steps set by the teacher in the Course Editor. The system synchronizes the triggered actions and the points of view changes as defined in the Course Editor, in order the user to watch the steps properly.

Figure 2. The menus for points of view and hidden objects

In the second case, the user must interact with the machine without any help. For that, he can explore the 3D environment, changing the point of view of the camera. A small menu (see figure 2) in the upper left side of the screen shows all the options. These points of view are predefined and stored in an XML file that describes the machine as we will see later. Paths between different points of view are also predefined. This way, the camera doesn't jump directly to the new point of view and the student doesn't get lost when changing the camera.

Once the user chooses the exercise option, he has to click in the pieces in the correct order. Each click (left or right) represents an action, e.g. left-clicking a screw represents the action of tightening it and right-clicking represents the action of loosening it. During the exercise, if the user chooses the correct step designed in the diagram of the Course Editor, the system displays the texts set for each action and triggers the animation linked to it. If he doesn't choose the right step, i.e. an action that doesn't follow the current one in the diagram of the Course Editor, the system displays a predefined text that tells the user he is making a mistake. As seen before, the selected action can be an incorrect one. In this case, the text defined in the Course Editor is displayed.

To improve the interactivity with the machine, the pieces that the user can interact with are highlighted when the cursor is on them (see figure 3). The user can also remove some pieces temporarily in order to watch other pieces correctly. Removed pieces appear in a small menu (see figure 2) and can be returned to their places. Moreover, removing a piece can be a part of the course.

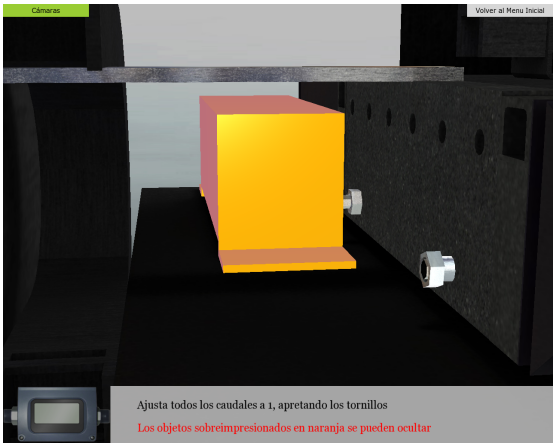

Figure 3. A highlighted piece in the 3D Simulator

In conclusion, the student can watch the steps of the designed course and repeat them easily with the help of the system.

IV. EDITOR/SIMULATOR CONNECTION

As the teacher, the user of the Course Editor is not supposed to be an expert in 3D animation. He will not be able to change any aspect of the 3D simulator, only the file generated by the Course Editor. Thus, the Course Editor and the 3D Simulator have to be perfectly synchronized in order the 3D Simulator to reproduce exactly what has been designed in the Course Editor.

In order to achieve this synchronization, we define an XML file denoted Virtual Course Simulation (VCS). This file is created by the Course Editor exactly in the way the 3D Simulator will be able to obtain the information. Figure 4 shows the structure a VCS file.

```
<vcs>
  <exercise>
    <action>
       <transition/>
       <transition/>
       …
    </action>
    …
  </exercise>
  <simulation>
    <action>
       <transition/>
    </action>
    …
  </simulation>
</vcs>
```

Figure 4. Overview of a VCS file

The root of the document tree contains the name of the course and the path of the file to open the corresponding machine.

```
<vcs name="example" machine="myMachine.xml">
```

There are two main elements in the document: *exercise* and *simulation*. The element *exercise* contains exercise's description in its attributes:

```
<exercise description="Balance all the flows">
```

The element *exercise* contains elements that contain the information about the steps that must be taken during the exercise and called *action*.

```
<action id="9" name="tighten screw" type="action" module="carriage Y" piece="screw" action="tighten" speech="This is a correct step">
     <transition id="12" />
     <transition id="49" />
</action>
```

The attributes of the element are *id*, *name*, *type*, *module*, *piece*, *action* and *speech*. The attribute *type* can be *start*, *action*, *end* or *incorrect*, as described before. The attribute *speech* is the text that will be displayed when taking this step. The elements called *transition* show which step can be taken after the current one. Any action that doesn't follow the current one makes the system to display a predefined error text. However, an allowed action can be an incorrect one and the system will display the error text, defined in the attribute *speech*.

The element *simulation* comes after the element *exercise* and it is very similar.

```
<simulation description="the simulation">
```

In this case the elements that contain the information about the steps have a new attribute. The attribute *camera* indicates the id of the point of view used to watch the current action.

```
<action id="0" name="tighten screw 1" type="start" module="carriage Y" piece="screw 1" action="tighten" speech="now we tighten the screw" camera="4">
       <transition id="2" />
</action>
```

Note that the actions in the element *simulation* can only have one transition, since simulation is a sequence of actions with no different options.

In summary, the VCS file contains all the information about the diagram designed in the Course Editor classified tidily. The element *action* contains all the information concerning the squares of the diagrams and the element *transition* all the information concerning the arrows.

V. MACHINE DESCRIPTION

The VCS file is essential for synchronizing the Course Editor and the 3D Simulator, but it is not less important that both applications work with the same machine. Besides using the same 3D model, it is necessary that the machines used in both applications have exactly the same characteristics, i.e. all the modules, pieces and actions defined in the Course Editor must be defined in the 3D Simulator.

Therefore, we defined another XML file, called Virtual Machine Markup Language (VMML), which contains all the information needed to understand the machine's functionality (see Figure 5).

```
<machine>
  <module>
    <piece>
       <action>
          <callback/>
          <translate/>
          <rotation/>
          …
          <hide/>
          <measure/>
          …
       <action/>
       …
    </piece>
    …
  </module>
  …
</machine>
```

Figure 5. Overview of a VMML file

The root of the file contains the path of other files that contain information about the predefined points of view and measures related to the machine and its interaction.

```
<machine name="myMach" cameras="MyCameras.xml" measures="measureHUD.xml">
```

In this case, the file located in the path defined in the attribute *cameras* contains the predefined points of view for the camera and the paths that the camera will follow when changing the point of view.. The file described in the attribute *measures* defines the Head-Up Display

(HUD) that shows measures linked to some pieces. It contains HUD's placement, aspect, piece names and initial values. If new similar files were needed, the element machine would contain their paths.

The main elements of the XML file are *modules* and *pieces*. The structure of the file follows the structure of the machine, i.e. if a module contains a piece in the machine the element that corresponds to the module contains the element that corresponds to the piece. This structure is important in order the system to animate all the pieces or the modules that are inside a module when animating such module. For example, it is usual that a machine has a carriage in each axis; X, Y and Z. If carriage Y's movement is dependent of carriage X's movement the structure of the file will be:

```
<module name="carriage X" file="carX.3DS">
    <module name="carriage Y" file="carY.3DS">
        <piece name="screw 1">
```

Note that the attribute *file* can appear in any module and piece. The geometry of a module or a piece can be saved in a specific file or it can be part of a file defined in a higher level. In the second case, it is crucial that the name of the piece inside the 3D model is the same as the one defined in the VCS. Furthermore,

Each *piece* element contains the list of actions that can be done interacting with it.

```
<action name="hide" type="click_right" duration="1.0">
```

where the attribute *type* indicates the interaction type, e.g. click_left, 'a', etc. and the attribute *duration* sets the duration of the action. This number is not needed during the exercise, but when running the simulation, it indicates how long the system has to wait until it triggers the next action. It is important that the duration is well defined. If the duration is too small, a premature change of point of view can make the action invisible and if the duration is too high, the simulation can be boring for the user.

Inside the element *action*, the file defines what happens when activating such action.

- The element *callback* links an animation saved in a file to the action. Note that it is not necessary that the animation works in the current piece, e.g. in the following case the animation works in the module "carriage Y". This characteristic could be applied to any of the following elements.

```
<callback module="carriage Y" piece="NULL" file="carriageYcallback.txt" />
```

- The element *translate* defines the translation that will be applied to the piece when activating the action.

```
<translate x="0.0" y="0.0" z="0.1" />
```

- The elements called *rotation* define the rotation that will be applied to the piece by giving an angle and an axis. In this case, it could be useful that the system accepts more than one element of this type.

```
<rotation axisX="0.0" axisY="0.0" axisZ="1.0" angle="-0.5"/>
```

- The element *hide* sets that this piece will be removed from the 3D machine when activating the current action. Moreover, it is possible to define the animations that will be triggered when hiding the piece or when it returns to the 3D scene. These animations can be very helpful for obtaining a more impressive result. For example, when removing screw, an animation that represents its rotation can be triggered, making the action more realistic and more helpful for the student.

```
<hide hidecallback="hideScrew.txt" returncallback=" returnScrew.txt"/>
```

- As stated before, in some machines, moving some pieces makes some parameters to change. The VMML file takes this aspect into account and defines an element called *measure*. The change applied to the parameter is defined by the attributes. Sums, products, exponentials and even value tables have been implemented, but the system is prepared to easily add a new formula.

```
<measure name="caudal Z1" product="0.95" />
```

The main goal of the VMML file was the simplicity of its structure so as to easily add new features required by a new machine. So, besides the possibility of designing any structure of modules and pieces, without losing any information about the structure of the machine, any new feature can be added inside the element *piece* and any new action can be added inside the element *action*.

VI. CONCLUSION

In the project MACHS we developed a system that makes creating Serious Games easier. The user of the Course Editor can design the course without taking into account any aspect related to 3D Animation or Computer Science.

The user designs the diagram that represents the course that the students will run in the 3D Simulator and doesn't need to work in the 3D Simulator. It reproduces the designed course automatically.

Several aspects of the Course Editor make it a friendly interface. Mainly, the 3D reproduction of the machine helps the user creating the desired diagram. The 3D scene inserted in the authoring tool highlights the chosen piece and shows the selected point of view in order the user to have the possibility to check he has chosen the correct features for the course. The 3D scene also reproduces the chosen actions.

The election of the pieces can be made by choosing the name in a menu, but it can also be made by clicking in the 3D machine.

For the synchronization of the Course Editor and the 3D Simulator we designed two new XML files called VCS and VMML. The VCS file contains the information saved in the diagram of the Course Editor and the VMML file describes the structure of the machine, its components

and their behaviour. Despite the fact that both files have a simple structure, they contain all the information needed for the correct running of the system.

Moreover, the simplicity of the structure of the files makes them valid for future improvements in the system. The structure of the files is designed to add new elements easily and without losing the information already inserted.

VII. Future Work

The project MACHS is only the first step of a long way that we intend to walk. Therefore, there are several aspects that need to be improved in the system and there are some features that we want to incorporate in the system.

Regarding the Course Editor, instead of working only with items, we plan to implement group of items. We reckon that working with subdiagrams inside the main diagrams will help the user understand the structure of the course. Besides, the user will be able to watch the designed simulation inside the Course Editor, not only the actions separately. This way, the user will be able to evaluate his work without opening the 3D simulator.

Regarding the 3D Simulator, our experience in 3D animation leads us to believe that using virtual characters is really helpful for this kind of applications. The interface becomes friendlier if there is an avatar talking with the student instead of a HUD that shows the text. Moreover, during the simulation, the virtual character could show how to do each action, e.g. the avatar shows how to operate a part of the machine and which tool to use. This way, students' learning would be much better.

The incorporation of a virtual character in the system leads to a higher complexity of the XML files designed for the project MACHS. Nevertheless, we believe that the simple structure of such files makes easy to add new features.

Finally, we see that the system developed in the project could have another application that make it complete. Now, we assume that the user of the Course editor, the teacher, doesn't have to do anything with the definitions of the modules, the pieces and their interaction options, i.e. the VMML file. However, we plan to develop an application called Machine Editor that will allow the teacher to define the VMML file easily.

This way, the teacher could take any 3D geometry and define its behaviour. Then, in the Course Editor he could have exactly the desired machine, not the one designed for others. So, the designed courses would be perfectly adapted to students' needs.

References

[1] J. Alvarez, and O. Rampnoux, "Serious Game: Just a question of posture?", *Artificial & Ambient Intelligence, AISB'07*, pp. 420–423, April 2007

[2] 3Dsolve Home Page, *www.3dsolve.com*

[3] BreakAway Home Page, *www.breakawaygames.com*

[4] PIXELearning, *www.pixelearning.com*

[5] A. Cabas Vidani, L. Chittaro, and E. Carchietti, "Assessing Nurses' Acceptance of a Serious Game for Emergency Medical Services", *VS-GAMES '10 Proceedings of the 2010 Second International Conference on Games and Virtual Worlds for Serious Applications,* 2010

[6] R. Siqueira, and F. L. S. Nunes, "Applying Entertaining Aspects of Serious Game in Medical Training: Systematic Review and Implementation", *SVR '11 Proceedings of the 2011 XIII Symposium on Virtual Reality*, 2011

[7] S. Göbel, S. Hardy, V. Wendel, F. Mehm, and R. Steinmetz, "Serious games for health: personalized exergames", *Proceedings of the international conference on Multimedia*, 2010

[8] ElderGames Home Page, *www.eldergames.org/*

[9] MIMICS Home Page, *www.mimics.ethz.ch/*

[10] L. Chittaro, and R. Ranon, "Serious Games for Training Occupants of a Building in Personal Fire Safety Skills", *VS-GAMES '09 Proceedings of the 2009 Conference in Games and Virtual Worlds for Serious Applications*, 2009

[11] N. Haferkamp, and N. C. Krämer, "Disaster readiness through education - training soft skills to crisis units by means of serious games in virtual environments", *EC-TEL'10 Proceedings of the 5th European conference on Technology enhanced learning conference on Sustaining TEL: from innovation to learning and practice*, 2010

[12] C. Linehan, S. Lawson, M. Doughty, and B. Kirman, "Developing a serious game to evaluate and train group decision making skills", *Proceedings of the 13th International MindTrek Conference: Everyday Life in the Ubiquitous Era*, 2009

[13] A. Hogue, B. Kapralos, and T. Pierce, "A serious game for collaborative intercultural business communication", *Proceedings of the 13th International Conference on Humans and Computers*, 2010

[14] M. Q. Tran, and R. Biddle, "Collaboration in serious game development: a case study", *Future Play '08 Proceedings of the 2008 Conference on Future Play: Research, Play, Share*, 2008

[15] E. Vasconcelos, C. Lucena, G. Melo, M. Irving J.P. Briot, V. Sebba et al., "A Serious Game for Exploring and Training in Participatory Management of National Parks for Biodiversity Conservation: Design and Experience", *SBGAMES '09 Proceedings of the 2009 VIII Brazilian Symposium on Games and Digital Entertainment*, 2009

[16] M. A. Zielke, M. J. Evans, F. Dufour, T. V. Christopher, J. K. Donahue, Phillip Johnson et al., "Serious Games for Immersive Cultural Training: Creating a Living World", *IEEE Computer Graphics and Applications, Volume 29 Issue 2*, March 2009

[17] M. Hays, H. C. Lane, D. Auerbach M. G. Core, D. Gomboc and M. Rosenberg, "Feedback Specificity and the Learning of Intercultural Communication Skills", *Proceeding of the 2009 conference on Artificial Intelligence in Education: Building Learning Systems that Care: From Knowledge Representation to Affective Modelling*, 2009

[18] W. L. Johnson, "Serious Use of a Serious Game for Language Learning", *International Journal of Artificial Intelligence in Education archive Volume 20 Issue 2*, April 2010

[19] W. L. Johnson, H. Vilhjalmsson, and S. Marsella, "Serious Games for Language Learning: How Much Game, How Much AI?", *Proceeding of the 2005 conference on Artificial Intelligence in Education: Supporting Learning through Intelligent and Socially Informed Technology*, 2005

[20] A. Sanchez, and P. A. Smith, "Emerging technologies for military game-based training", *SpringSim '07 Proceedings of the 2007 spring simulation multiconference - Volume 3*, 2007

[21] Games2train Home Page, *www.games2train.com*

[22] S. Rilling, U. Wechselberger, and S. Mueller, "Bridging the Gap Between Didactical Requirements and Technological Challenges in Serious Game Design", *CW '10 Proceedings of the 2010 International Conference on Cyberworlds*, 2010

[23] M. Rosendo, T. Buriol, K. de Geus, S. Scheer, and C. Felsky, "Towards the Development of a 3D Serious Game for Training in Power Network Maintenance", *VS-GAMES '11 Proceedings of the 2011 Third International Conference on Games and Virtual Worlds for Serious Applications*, 2011

[24] S. Göbel, L. Salvatore, R. Konrad, and F. Mehm, "StoryTec: A Digital Storytelling Platform for the Authoring and Experiencing of Interactive and Non-linear Stories", Proceedings of the 1st Joint Int'l Conference on Interactive Digital Storytelling, ICIDS pp. 325–328. 2008

GENEXIS Platform and Products

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Abstract - GENEXIS is an e-learning solution specially developed to give teachers a power of modern software applications for creation of learning content, sharing of content with other teachers and educating their students in a manner that corresponds to the modern internet-saturated life. GENEXIS provides content editing, training, printing and testing services as well as allows creation of courses. GENEXIS innovative technology of content generation introduces the new way of e-learning. Any teacher can use this innovative tool to create exercise templates with changeable parameters. The article explains in more details the innovative process of exercise creation, application of the GENEXIS functionality and utilization of the GENEXIS platform in Latvia, Slovakia and other EU countries.
Keywords: Education, E-learning, Training, Testing, Exercise Generation

I. Introduction

The name 'GENEXIS' is formed from two words "generate exercise". And these two words represent the principle which was introduced in the late 2007 through GENEXIS v.1. It contained the first prototype of the exercise editor based on content generation principle. This principle gave birth to a multitude of innovative ideas for systems' application in educational processes.

GENEXIS v.2. was developed in 2008 and its approbation was performed as a part of Leonardo da Vinci Transfer of Innovation project "Computer based Exercise Generation and Evaluation System for Mathematics, Physics and Chemistry Subjects – GENEXIS" (2008-2009). The testing and evaluation of GENEXIS was carried out in vocational education and mainstream schools in 5 different countries – Latvia, Slovakia (Elfa s.r.o), Lithuania, Estonia and the United Kingdom.

Currently GENEXIS is in the process of being adapted also in Italy, Spain, Greece, Sweden and Turkey as a part of another LdV project 'E-learning Exercise GENEXIS System – EEGS', lead by the Italian company "Docusys srl".

Based on the GENEXIS platform, public educational portal "Uzdevumi.lv" was built and introduced at the beginning of 2009 in Latvia. At the moment it is already used by 20% of Latvian schools. Portal is supported by the Municipality of Riga City and it has been integrated with leading school e-journal system in Latvia – 'E-klase'.

Starting from 2010 GENEXIS is also being used in Slovakia as software for modernisation of educational processes in schools within the framework of the project **'MVP Slovenska' (modernizaciavzdelivania.sk).**

II. MAIN FEATURES AND ADVANTAGES OF GENEXIS

GENEXIS is an e-learning solution based on exercise generation engine that makes the learning process more efficient, attractive and engaging. It is based not only on „just-in-time" and „just-for-you" principles but also on „learning-by-doing" principle.

The initial idea of GENEXIS was to resolve two great problems of teaching and learning process:

- Costs for development of the exercise database and support;
- Inefficient consumption of teaching time on student knowledge evaluation and monitoring.

It has been done by providing an attractive, engaging and simple learning and teaching environment that reflects the modern internet-saturated life.

A. What can GENEXIS offer right now? What are its advantages and benefits?

- By using GENEXIS, teachers can produce core skills materials that can be delivered online or on paper;
- Teachers can use readymade materials created by other teachers;
- An exercise created in GENEXIS has hundreds of variations that give unlimited training opportunities to learners.
- GENEXIS can be integrated with Moodle or other WEB portal;
- The system has been created for teachers with the help of teachers for user-friendliness and time economy.

B. What are the main features of GENEXIS? What makes GENEXIS special?

The core feature of GENEXIS is exercise generation. Typically, a student needs to practice repeating the same sort of problem solving activities to understand the logic of the solution. To facilitate this, education materials offer a few variations on each problem type.

GENEXIS is different: in the GENEXIS system any exercise can be replaced with an exercise template which describes a type of problem in general terms. An exercise template is easy to build using the exercise editor and can take as little as 10 minutes.

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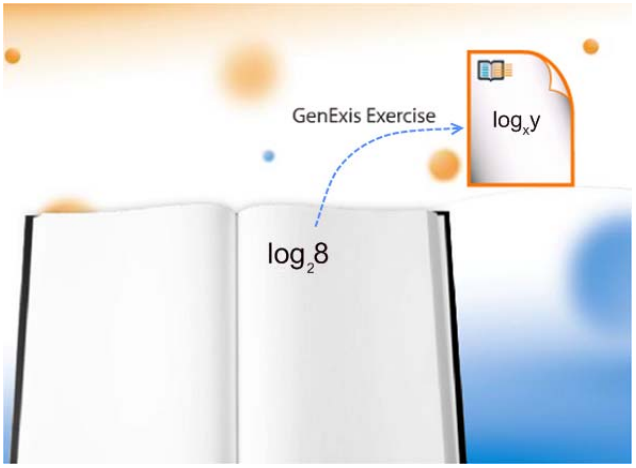

Fig.1 Transformation of an exercise into a GENEXIS exercise template

The specific content of the exercise template is generated anew every time it is used, providing an unlimited number of variations with no additional effort.

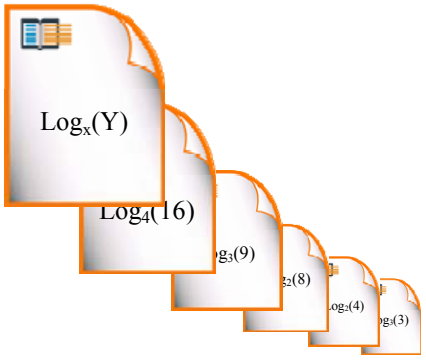

Fig.2. Exercise generation principle

Exercise templates and other related materials can be biased to different vocational areas to make the learning more relevant and attractive to the students. GENEXIS also makes it easy for the teacher to differentiate ability levels within a group using the same exercises.

GENEXIS provides exercise answer evaluation (correct/incorrect) and step-by-step solution for all exercises. When student solves a problem (task/exercise) and submits the answer, GENEXIS automatically checks if the answer is correct. GENEXIS is able to verify different types of user answers. This could be text answer, number and multiple choice answers. Additionally GENEXIS is able to validate answer with mathematical or chemical formulas in it. When answer has been validated GENEXIS shows a step-by-step solution process for the task and provides correct answer.

These features reduce the routine grind of comparing student answers to the answer key as well as enable students to understand problems better and learn from their mistakes.

III. HOW CAN ANYONE USE GENEXIS EXERCISES?

GENEXIS exercises can be used in three different and flexible ways - **a major advantage of GENEXIS over traditional textbooks.**

A. Training

GENEXIS WEB Portal for students provides individualized training and practice opportunities, enhanced with a simple statistics tool showing study progress. Through GENEXIS WEB Portal students can search for available online courses and apply to them. GENEXIS WEB messaging functionality is used to notify student about the activities within the system, e.g., exams, course application status, etc. Students can expand the use of the messaging functionality by sending messages with attachments to teachers and other students within their educational organization.

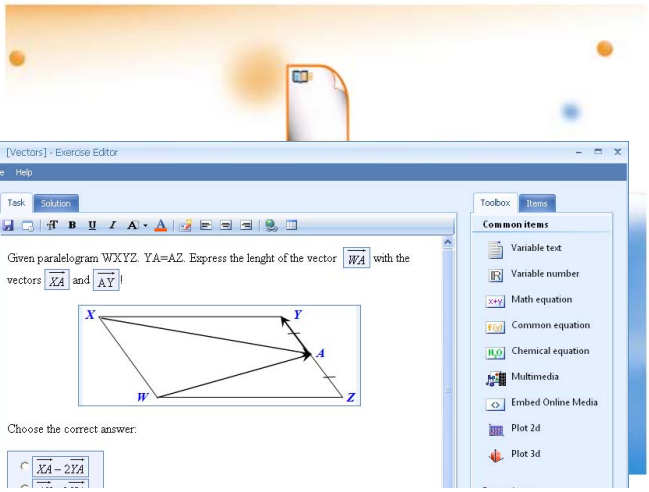

Fig.4. Three basic ways of using GENEXIS exercises

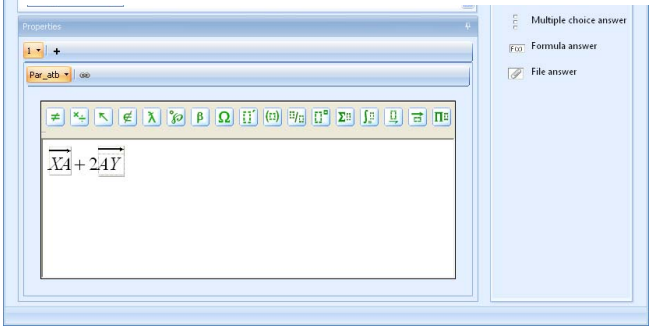

Fig.3. GENEXIS exercise editor

GENEXIS provides advanced way of learning through WEB. The learning is intended as follows:

- Understanding the theory. Theoretical material can be given as a part of the course and can contain multimedia materials and links to related materials on WEB.

- Applying the theory in practice. This is done by solving the exercises. Exercises can contain task and solution parts. By running the same exercise again student will get another variation of the task.
- Learning by Doing. After completing an exercise student receives an evaluation of the answer and full step-by-step solution. This is how student can understand the topic on his own (without assistance). By repeating the same exercise again he can reapply received knowledge.
- Checking the overall level of understanding the course subject by completing the test(s).

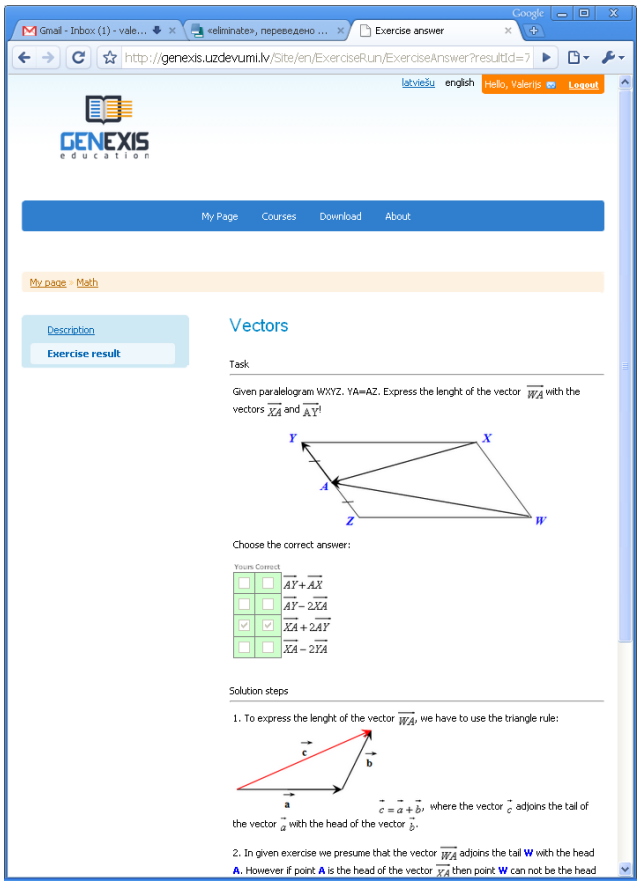

Fig.5. Example of an exercise in GENEXIS WEB Portal for students

B. Courses

Teachers can send invitations to the students from GENEXIS Desktop Application. Invitations to courses are delivered to students via e-mail and GENEXIS WEB Inbox. Whenever a student accepts an invitation to a course, the course content becomes visible on GENEXIS WEB main page. Each course can contain theory, exercises, tests and scheduled control works.

C. Printing

Traditional printed educational materials can be produced using GENEXIS exercises.

A range of printing options support the creation of take-home tests with answers, handouts of solution examples and question sheets for written tests and exams. Teachers themselves admit that printing is one of the most useful and frequently used applications of GENEXIS content.

D. Testing

GENEXIS includes a system of online knowledge evaluation based on scheduled, timed tests. Using exam creation wizard it is possible to create a test fast and easy.

Tasks for the test are generated only at the moment when pupil chooses to run exam. It is not possible to somehow clarify the content of tasks in advance.

After the test has been completed it is possible to see pupil statistics which contain score and time spent on tasks. If pupil was not present on the exam then it will be shown. Teachers are able to see each task, step-by-step solution and result. If it is required teacher could change particular question result and must leave the comment. When teacher has finished checking exam scores, tests are set as checked and results are available to pupils on WEB. Pupils can see personal scores, score corrections done by teacher and comments.

GENEXIS testing plus exercise generation feature is very useful when it is needed to assess individual progress of students in the group. By using this feature it is impossible to prepare exercise/exam results before the exam or copy them from other students. Also this feature can secure the creation of unique home works for each student.

E. Additional feature: Exchange of content

It is possible to publish content to public library or copy content from it. That's how the content can be spread among the teachers and schools.

It is also possible to send content from teacher to teacher in another school by using special transfer form. This way teachers lecturing on similar or related school subjects can develop their own community and interact with each other through GENEXIS.

IV. MVP SLOVENSKA PROJECT

Starting from 2010 GENEXIS is also being used in Slovakia as software for modernisation of educational processes in schools within the framework of the project **'MVP Slovenska' (modernizaciavzdelivania.sk).** During the four project years 7300 Slovakian teachers will undergo the GENEXIS training courses. The specific objective of the project is to upgrade and modernize the content, methods and the outputs of the learning process in the modern school of the 21st century. It is also aimed at increasing the proportion of teachers participating in lifelong learning process in order to obtain and develop competencies needed for the modern knowledge-based society.

During the first 6 months in 2011 several groups of teachers have created 988 exercises that have been used 4889 times. The WEB portal has been used by the 3 086 unique users that have visited 39 376 pages. This shows good GENEXIS application and interest amongst the teachers in using the software.

V. APPROBATION OF GENEXIS IN EU SCHOOLS

Approbation of the GENEXIS system was performed as a part of Leonardo da Vinci Transfer of Innovation project "Computer based Exercise Generation and Evaluation System for Mathematics, Physics and Chemistry Subjects – GENEXIS". The testing and evaluation of GENEXIS was carried out in vocational education and mainstream schools in 5 different countries – Latvia, Lithuania, Estonia, Slovakia and United Kingdom. With the help of partnership organizations – Business Innovation Center of Latvian Electronic Industry (Latvia), KTU Regional Science Park (Lithuania), Baltic Innovation Agency (Estonia), Elfa s.r.o. (Slovakia), Accent International Language Consultancy (UK) – 1 till 5 educational organizations were selected in each country to participate in the approbation of GENEXIS. Altogether there were 21 educational organizations involved in the project.

A. Project 'E-Learning Exercise Genexis System'

The adaptation of GENEXIS on wider European level is currently being done in five other countries as a part of Leonardo da Vinci Transfer of Innovation project "E-learning Exercise Genexis System - EEGS". The

translation of GENEXIS has bee done by the project partners from 5 different countries – Italy (Docusys srl), Greece (SQLearn Ltd.), Spain (Fondo Fomacion Euskadi, S.L.L), Turkey (Gazi University) and Sweden (Swedish TelePedagogic Knowledge Centre AB). The approbation process in vocational education institutions and schools will be launched at the end of 2011 and finalized in the middle of 2012. It is planned to involve 50 institutions to test the systems functionality, educational content and user guidelines that are currently being developed.

The main objectives of the project are: to introduce a management system of ICT content in the VET sector of partner countries; to create a network of VET institutions that are using one e-learning portal and share the library of content; to provide teachers and trainers with technical skills necessary for the usage of the system and content creation. The project supports the Leonardo da Vinci Programme's operational objective to develop innovative ICT based content, services, pedagogies and practice for lifelong learning.

VI.GENEXIS PLATFORM

GENEXIS is used as a base platform for Latvian educational portal www.uzdevumi.lv and Ukrainian educational portal domashki.com.ua. GENEXIS exercise database and exercise generation engine is used to deliver educational content to the public WEB portal, so that any person can use it for self-training.

In Latvia e-learning portal Uzdevumi.lv serves thousands of pupils every day, delivering practical exercises in more than 10 subjects from the school curricula for grades 1 till 12.

All subjects are developed by teachers according to the Latvian Ministry of the Education standards. In summer 2011 the size of educational database had reached 10 000 (Fig.6) exercises, and each exercise had at least 50 variations.

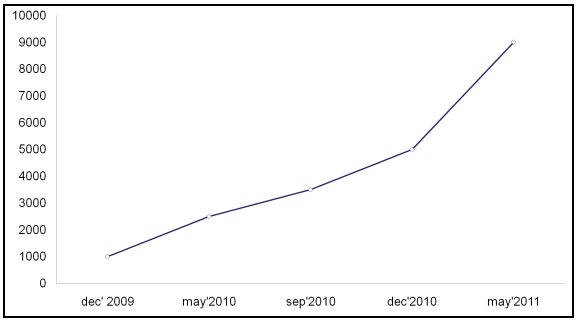

Fig.6. Growth of exercise database

This is the biggest database of exercises in Latvia and one of the biggest in the world. During the study year 2010/2011 portal was actively used by 41 000 pupils, which makes up 20% of all pupils in Latvia. 2 818 000 exercises were solved during that study year.

VII. SUMMARY

GENEXIS is an e-learning solution based on exercise generation engine providing all of the traditional features and benefits of online learning as well as ensuring additional advantages of content generation and online platform.

GENEXIS helps making the learning process more efficient, by generating unlimited random variations of given exercises on any theme or subject.

Using GENEXIS, teacher can produce core skills materials that can be delivered online or on paper.

GENEXIS is designed to help teachers engage students in the learning process so that they can achieve consistent and measurable improvements in their performance.

GENEXIS uses a methodology based on exercise generation which is stimulating, varied and relevant to the vocational interests of the learner.

The system has been created for teachers with the help of teachers to be easy to use whether the student is home-based, work-based or in the classroom.

GENEXIS helps making teaching and learning more productive and less frustrating, benefiting everyone involved in the education and training process.

GENEXIS system has been adopted and tested in nine European countries within the framework of two Leonardo Da Vinci Transfer of Innovation projects.

GENEXIS system is already used by clients from private and public sectors in Latvia, United Kingdom and Slovakia.

Everyday project work still continues on improving GENEXIS functionality and design to make it even better. We have to thank our clients and partners in different countries for their support and feedback. Every opinion is taken into account and it only helps us to make right decisions for GENEXIS future and to set forward new goals that need to be achieved.

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REFERENCES

[1] http://www.dataprogrupa.com
[2] http://www.genexis.lv
[3] http://www.uzdevumi.lv
[4] http://eegs.euproject.org/index.cfm
[5] https://www.modernizaciavzdelavania.sk

Automated Testing of Case Studies in Programming Courses

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Abstract — **The majority of Learning management systems (LMS) provide the functionality only for evaluation of built-in tests activities without any support for evaluation of case studies, which are frequently used in programming courses. These have to be checked manually by an instructor, what is time consuming especially in case if courses are attended with a high number of students. In this paper we propose an automated submission process decomposed in several phases. We provide a detailed description of particular phases with selected tools as jPlag and PMD. The aim of our work is to combine existing tools into one coherent system connected with LMS (Moodle) and IDEs and not to go a way of implementing a new standalone validation and assignment system. We present also some partial results and experiences using jPlag and PMD tools on our courses – Programming, Object oriented programming and Technologies Java.**

I. INTRODUCTION

One of the key parts of teaching is the evaluation process and examination. Its aim is to objectively assess students' knowledge that they gained by attending a course. Test preparation requires a plenty of time, however the evaluation may be even more time consuming.

Automated test evaluation is supported by the majority of currently used Learning management systems (LMS) as Moodle, Sakai, OLAT, etc. [1]. However, the problem occurs when we would like to evaluate student's skills by implementing a program or working on some case study. LMS systems provide mainly the environment to upload documents relevant for a case study to the system, but any ability to evaluate at least some formal aspects of the student's work is missing. These tasks have to be done manually by the lecturer.

This paper is dedicated to the problem of automated evaluation of case studies in programming courses. Related work in automation of programming assignment submission and evaluation is mainly oriented in developing new or enhancing existing tools with a specific purpose as MARMOSET [2] or ProgTEST [3]. Rather than going this way, we decided to combine existing tools into one functional system with added value. In this paper we propose an architecture overview of a web service in the scope of existing environment of LMS and IDEs already used in our courses with some partial tests of submission process sub-steps.

The paper is organized as follows. In Section II we provide an overview of submission process decomposition into sub-processes and in Section III we describe these sub-processes in more detail with deeper focus on used tools as *jPlag* and *PMD*. In Section IV we propose an architecture overview of a future system connected to an existing infrastructure. The Section V describes some experimental results acquired during two years running courses *Programming*, *Object oriented programming* and *Technologies Java*.

Although we target on the area of case studies from programming courses, concepts presented in this paper may be used also in non-programming areas.

II. SUBMISSION PROCESS DECOMPOSITION

Testing of a programming case study involves verification if the program solves given problem and fulfills required criteria and measurement the quality of a program. Assignment testing may be divided into two types: static analysis and dynamic testing referring to whether a program needs to be executed while it is being assessed [4]. Dynamic testing is furthermore divided on a white-box testing, when the assessment process is done by looking into source code structure, or black-box testing, when the assessment is done by functional behavior. In addition there are evaluated characteristics as correctness, complexity, reliability or style of a program [5]. Our work focuses on both static and dynamic testing in separate steps of testing procedure.

The submission process can be decomposed on several sub-processes, where each of them is used for evaluation of specific part of submitted case study. The results of some sub-processes may be binary (the requirements were full-filled or not), other may provide score in percentage.

We have decomposed submission process into following steps:

- Evaluate a file structure of an uploaded bundle.
- Verify the originality of a solution.
- Compile a program.
- Verify the programming principles (OOP).
- Check the correctness of functional parts based on unit tests.
- Check the proper functionality of the program based on given inputs and outputs.
- Create a report based on results of previous steps with the final score.

The composition and a sequence of steps of the evaluation process are illustrated in the Fig. 1. The sub-processes 2 and 3 require a parameter – threshold in percentage, above which the program is considered a plagiary and threshold defining how many rules of a particular programming methodology, e.g. object oriented

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principles (OOP), may fail and the assignment is still accepted. Other sub-processes provide binary results meaning that assignment is either accepted or rejected. In the second case a failure report with a detailed description is sent back to a student. Naturally, a student has to correct indicated failures and upload the assignment once again.

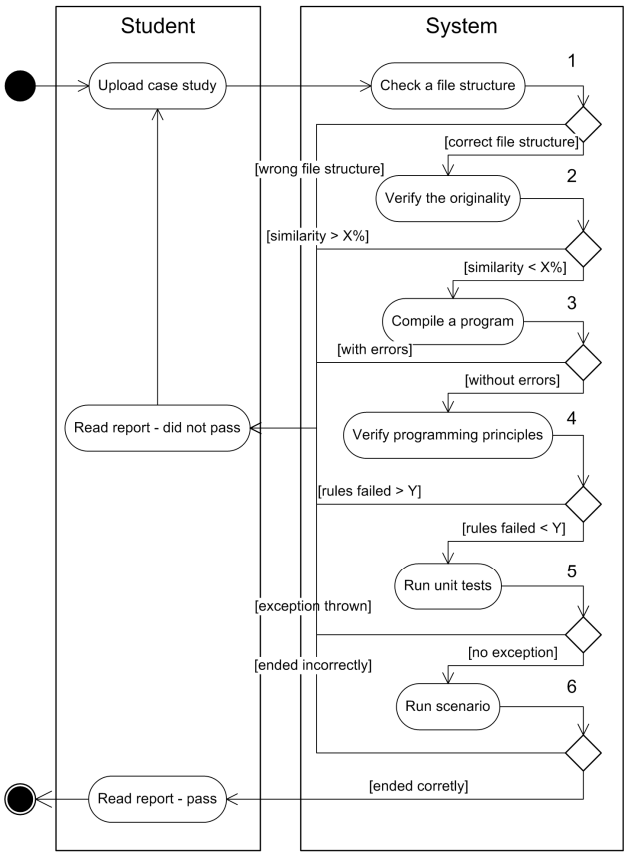

Figure 1. Activity diagram of a decomposed submission process

The submission process may be completely automated, or may work as a sieve, filtering students, who just try to submit an assignment of someone else. In later case, the student will be allowed for a personal defense only when passing all submission sub-processes. The continuous monitoring of student's progress may be also an asset, forcing the student to work gradually, not at once just before the final examination.

III. Phases of a Submission Process

A. File Structure Evaluation

Finalized case study on a programming course usually comprises of various data files. There are not only source files, but also documentation (may be generated from a source files during checking phase), executable, external libraries, readme file or other files requested by the instructor. On our courses we prefer Game Based Learning (GBL) [6] where students are implementing a game during a semester. Therefore our students are requested to upload, besides previously mentioned files, also a user guide and a scenario how to complete the game successfully.

Checking the formal aspects of an uploaded assignment is definitely time saving and easy to be implemented either as a web service or as a plug-in in LMS. During this step, the uploaded bundle is unpacked and all required files are verified. If something is missing a student is asked to upload a bundle with right structure.

B. Verifying the Originality

To find plagiaries is labor demanding tasks, especially in courses attended for a high number of students. Finding a duplicate manually is usually an accident when student forgets to change a name in comments, or other document enclosed with an assignment or some weird bug is common for more than one assignment.

There exist several tools for automated plagiary detection. Usually their compare all pairs of assignments with various software metrics or compare structure of programs.

jPlag is one of such tools comparing the programs based on tokens coverage. Firstly it parses the input source code and converts it to a stream of tokens. After that the tokens are compared in pairs for determining the similarity of each pair. The similarity value is counted as the percentage of the token streams that can be covered [7].

jPlag tool is accessible as a web service, which may be important especially when it is aimed to be included into a larger system.

C. Verifying Programming Principles

There are available plenty of tools for static code analysis. From tools dedicated to Java programming language there could be mentioned open source tools as PMD [8] and Checkstyle [9] or commercial tools as JTest [10]. All these tools are aimed at scanning source code and report problems like inappropriate expressions (many nested if statements or loops), duplicated code, wrong variable naming, dead code as unused local variables, parameters and private methods, tight coupling or low cohesion.

We have decided for PMD because changeable rule sets, possibility to overwrite descriptive messages for violations and accessible plug-ins for Netbeans and Eclipse IDE.

D. Running Unit Tests

Object-oriented paradigm is widely used in introductory or basic programming courses. OOP may seem more appealing to students, but it sometimes orient students more on technological aspects. Thus the students have problems with designing a program or finding bugs in their application [11]. To solve this problem many universities introduced testing concepts in their programming courses [12].

As part of automated testing there may be realized unit tests prepared by students and also unit tests prepared by a lecturer. To support this approach, the students should be provided a library with interfaces and a set of empty unit test. This will navigate students which values to test and therefore help them to prepare unit test properly

E. Running scenarios

Depending on type of a case study, students may prepare a scenario to prove the right functionality of a program. This type of testing is more visible for programming assignment, where students implement a game. For instance an adventure game has a scenario how

to successfully accomplish it (go west, take sword, go north, kill a dragon).

Students may prepare an input scenario, which is bundled with a program and this way uploaded for testing. The automated testing system runs the scenario on program and evaluates its functionality.

Obviously this type of testing is adaptable only for programs accepting text input and explicit sequence of steps known before the program execution. Testing of a successful scenario may be implemented also through unit tests in some programs.

IV. An Architecture Overview

Rather than developing a new system from scratch, that will cover all phases of the submission process, we decided to interconnect existing systems and applications into one collaborating unit with added value. When designing the architecture of a submission system we came out from IDEs and information systems already used on our courses as Netbeans, Eclipse, LMS Moodle and student information system Mais.

The main evaluation component of a system, which glues other existing systems, is a remote web service *LANESS (LAzy and NEgligent Student Search)*. It accepts the assignment from a student, executes all validation steps and provides a result to the student through both an IDE and LMS Moodle.

The proposed system is not finished yet and we are working on the implementation. From the architecture point of view and internal processing of LANESS is decomposed into two parts:

- uploading the assignment from IDE to a web service and validation steps execution
- writing the results into LMS or other IS

A. *Uploading an assignment to the Web service*

The simplified architecture of an uploading process is depicted in Fig. 2. A student uses an IDE to work on an assignment (e.g. Netbeans or Eclipse – they provide the environment for various programming languages as Java, C, C++ etc.). When the program is finished, the student uploads the assignment to the web service for validation. This may be done only once during the semester, when the assignment is finished or more times after some milestones, depending on a validation mechanism. The web service executes all validation steps (file structure evaluation, originality verification, programming principles evaluation, etc.) and prepares a result report that is sent back to the student.

To provide a more user friendly environment, the uploading functionality is accessible directly from an IDE as an ANT task. This way a student is released from tasks such as compressing all files into one ZIP file, uploading the ZIP file through some web interface and downloading the result. All is done automatically through an ANT script that is executable directly from an IDE by one click. The student should take care only of a file structure, since all types of documents are required to be on a predefined place.

B. *Sending the Result into LMS*

When the assignment is validated by the LANESS service the result is sent back to a student providing a comprehensive feedback. The feedback helps a student to fix problems and fulfill all requirements to have the application accepted. The information about student progress is important also for a lecturer. For this purpose LANESS sends the shortened report to LMS.

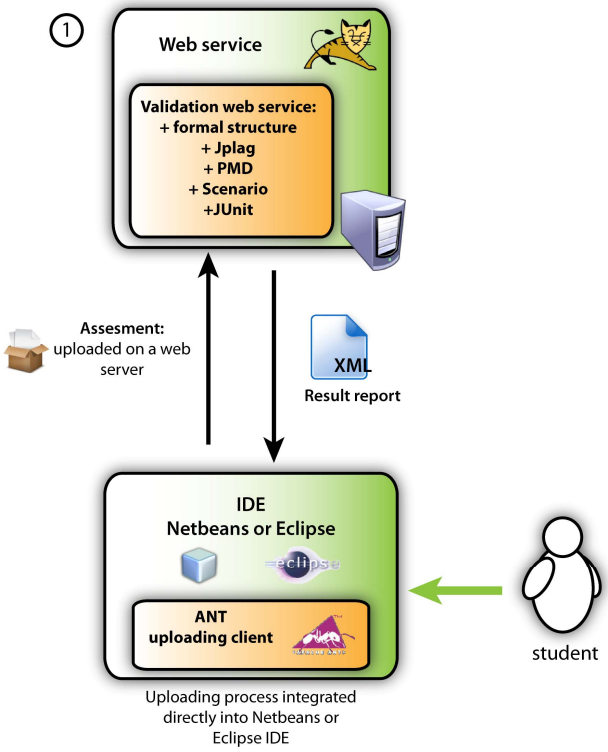

Figure 2. LANESS Architecture - uploading and evaluation part

C. *Sending the Result into LMS*

When the assignment is validated by the LANESS service the result is sent back to a student providing a comprehensive feedback. The feedback helps a student to fix problems and fulfill all requirements to have the application accepted. The information about student progress is important also for a lecturer. For this purpose LANESS sends the shortened report to LMS.

LMS systems are currently broadly used at the universities providing the environment with various features as sources management, submission assignment, grading, testing, calendar, etc. Since the grade or final evaluation on many courses comprises from more than one assignment (test/quiz + case study) and LMSs internally support test/quiz creation and evaluation, we want to integrate LANESS results directly into LMS (Fig.3). This will not force lecturers to manually transcribe the marks from external validation system into LMS.

LMS may be connected with a university IS (management of students, classes, schedules, etc.) where final marks will be sent when course is finished.

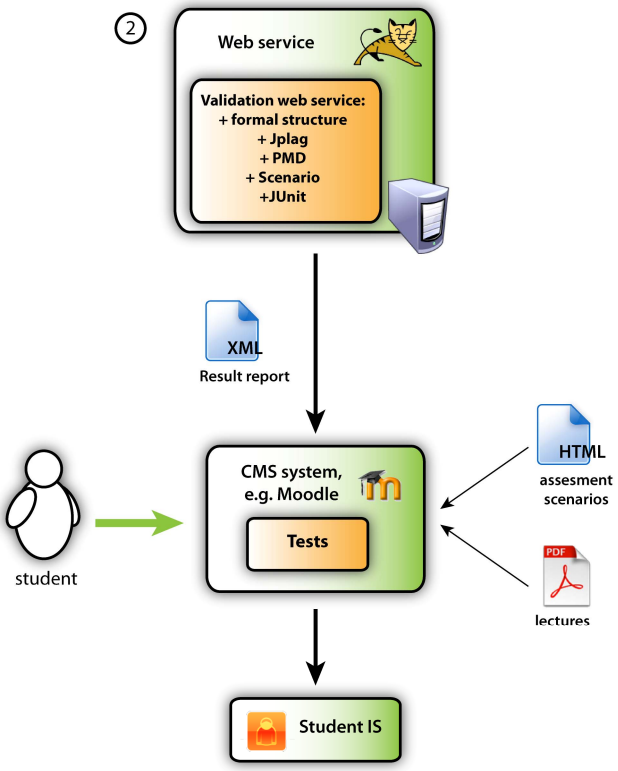

Figure 3. LANESS Architecture - writing results in LMS

V. Experimental Results and Future Work

We are trying to deploy this solution to the selected courses of undergraduate study programs at Faculty of Electrical Engineering and Informatics, Technical university of Košice, such as Programming, Object oriented programming (OOP) and partially at Technologies Java (TJava). These courses are one of the main courses of software engineering, where the number of attending students is between 200 and 400. The given numbers of students represent an interesting sample, where some of them are beginners in programming without any previous experiences, but some of them are advanced programmers with some habits. Obviously, such high numbers of students increase the probability of plagiarism, since manual checking all the assignments is a challenging task.

A. Case Studies and Scenarios

As was mentioned before, to increase students' motivation we prefer Game Based Learning [6], where students continuously work through semester on a game implementation following predefined scenarios. This type of education creates more space for students to be creative and to "play". Individual courses differ a little, for instance course OOP is denoted more to programming principles and technology is hidden as much as possible, whereas course TJava focuses more on special classes from Java SE and selected Java frameworks.

What they have in common are scenarios, which define steps guiding the students to accomplish specific goals (e.g. to learn difference between static and non-static methods), sometimes very similar to a tutorial. Because of these scenarios, part of a source code is similar for one case study and the remaining part depends on an approach and creativity of a student.

B. Present Submission Procedure

Until the system and LANESS service will be ready for a practical usage, we try to check all case studies manually. Manual submission control conforms to that presented in the second section. A lecturer firstly checks formal aspects of an assignment as documentation (user guide, system manual or Javadoc, UML diagrams). Secondly he checks if a program compiles without errors and if source codes comply with programming principles of a particular language through PMD tool. If some of the formal aspects are not fulfilled, the student is not allowed to continue in submission and is asked to fix all deficiencies and come again.

Naturally, in the opposite case, when the case study contains all required parts, student is asked to introduce his solution. Discussion between the lecturer and the student about student's ideas and approaches is the most pleasant part of the submission, however many times it turns into proving that a case study was not worked out by the student, but by someone else. This proving, besides checking formal aspects, consumes a lot of time and strengths of the lecturer. Here the automated testing of case studies may significantly help the lecturer to focus on final phase of a submission – evaluate students own approach to a solved problem.

C. Programming Principles Verification with a PMD Code Analyzer

To verify object oriented principles in Java programs we use PMD tool. The tool is bundled into a startup template (Netbeans project) that students download on the first meeting. It is executable directly from Netbeans IDE as an ANT task. PDM supports integration with up to 15 different IDEs, however we encounter a problem, where command line version returns more violations than plug-in version on the same source code.

We have prepared our own ruleset and translated description messages, because students had a problem to understand several violations. As an example, there could be mentioned frequently reported violation *cyclomatic complexity*. Students complained that official PMD explanation is too complex for them.

The result, which is our success, was improved readability of the source code produced by students. They get used to naming conventions, avoiding overcomplicated expressions, 3 or more times embedded if statements and many more, what are usual errors made by novice programmers.

D. Originality Verification with jPlag Tool

At present, verification whether a case study is a plagiary or not is done largely by lecturer's intuition. We have used jPlag Web Start client to test the sets of student's programs, but just as a post-validation after we have collected all the assignments.

The tests were realized on a sample of 183 assignments from the subject OOP taught in a winter semester 2010/2011 and 122 assignments from the subject TJava taught in a summer semester 2010/2011. The results are shown in Fig. 4 and Fig. 5 as histograms of programs' coverage. The coverage or similarity between two

programs is measured in percentage divided into intervals of a length of 10% and the Y-axis represents pairs of programs falling into a particular interval. The number of pairs is counted in (1), where *n* is number of realized comparisons (each program with all others).

$$(n \cdot (n-1)) / 2 \qquad (1)$$

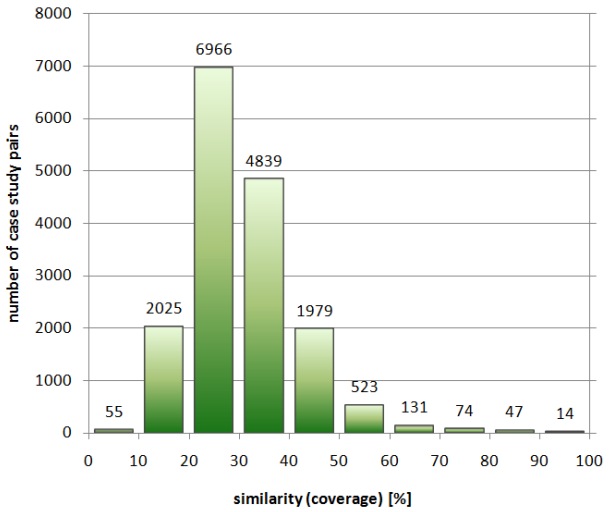

Figure 4. Histogram created by jPlag from assignments of a subject Object Oriented Programming

For instance, the algorithm of jPlag realized 16 653 comparisons among 183 programs from the OOP course. From the histogram in the Fig. 4 it is easy to see that similarity below 50% is a consequence of common scenarios and library provided to all students. Programs located in the interval of 50% - 70% coverage imply that students cooperated, but they added also their own implementation. Programs with the coverage above 80% are obviously plagiary. Counted from the jPlag report, 45 students (24,59% of all tested students) has the coverage of their programs higher than 80% and are considered to be cheating. 24,59% is rather a high number, which should be decreased in the future. The interval 70% - 80% should be considered manually by the lecturer, since there is a high probability that students cooperated, but not primarily with the aim to copy their programs.

Low number of program pairs above 80% coverage (61) on the one hand and a high number of cheating students on the other hand is given by the fact, that usually one student is an author of a program and another student copies the program with only minor changes. If we consider 50 students, where half of students worked on the assignments on their own and the remaining 25 copied the program from somebody from the first group we get only 25 pairs. Naturally, this is true only when a condition that one original is associated with only one copy is maintained. However, the task to seek out who is an author and who is plagiarist lies on the shoulders of a lecturer.

The result from a scan of TJava assignments (Fig.5) shows that a bigger part of the source code was common for all students. At OOP students implemented a text game, while at TJava students implemented a Minesweeper game with GUI. The limit of plagiary coverage is therefore shifted to higher percentage, because source code generated by Netbeans IDE represents a notable part of source code of the whole program. From a distinct difference of coverage, visible in Fig.5, between the interval 60%-70% and 70%-80% we may conclude that programs with coverage above 70% may be considered a plagiary. Programs falling into low coverage intervals are individual case studies implemented by skilful students.

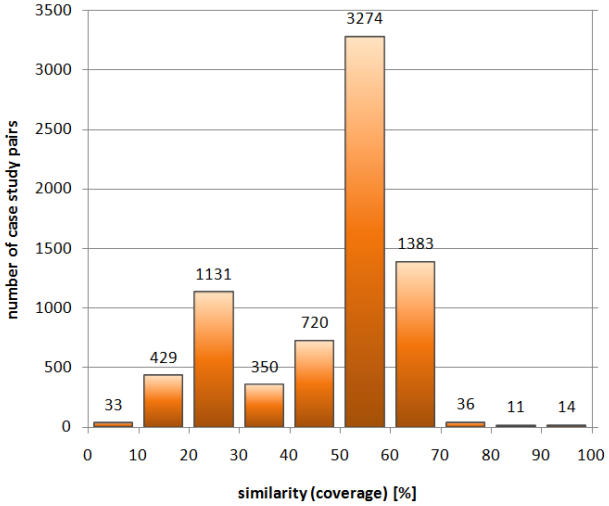

Figure 5. Histogram created by jPlag from assignments of a subject Technologies Java

E. Simple prove of the results

Because the proposed system is not fully functional and jPlag scan were realized after the end of a submission procedure, when the students were already graded, we have proved the results by questionnaires. The students were asked questions about their satisfaction with a course and a lecturer, how challenging was the case study, what they would change on a case study in the future, etc. The students whose programs were labeled as a plagiary were given a list of cooperating students (from the jPlag report) and should write if the list fits. They were assured, that their grades would be not degraded, if they own up.

From the questionnaires, we gained about 90% success in finding the plagiary. The result is thanks to truthful students (only when there is no threat of sanctions) quite high, but there should be considered some students who may not own up.

VI. CONCLUSION

High numbers of students attending courses, which are taught on more departments of a faculty in parallel, create better opportunities for lazy or worse students to cheat and copy programs from classmates. Manual control is time consuming and signs indicating a plagiary are easily overlooked by a lecturer.

This assumption is affirmed by the results from jPlag scans realized on assignments from OOP and TJava courses. We have verified the originality of a set of 183 OOP assignments, where 24,59% programs were marked as plagiary.

To speed up the submission process and to increase the number of detected plagiaries we propose a system for automated testing of case studies. The main part of the system is a web service LANESS responsible for

particular testing steps as file structure verification, originality verification, control of programming principles, etc.

The architecture of a presented system, currently in the phase of development, links to existing systems as LMS Moodle and IDEs used at our courses. We want to integrate the service directly into IDEs to be accessible just by one click and the reports visible in the systems that are already used at the courses. Adding a new standalone system and therefore increasing the complexity of the submission process is not a way we would like to go.

We have realized tests with PMD and jPlag tools. Students used PMD tool with adapted ruleset during the implementation through the whole semester. jPlag was used to scan assignments from two different subjects – OOP and TJava.

Future work will focus on finalization of the proposed web service and plugins into LMS Moodle. A key aspect is scalability, to easily adjust the web service for a new case study or a new course. Another thing which shouldn't be neglected are descriptive reports for students. Feedback provided by a web service should help students to fix problems and successfully proceed the submission process, not to make it more complicated and stressful.

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REFERENCES

[1] S. Kumar, A. K. Gankotiya, and K. Dutta, "A comparative study of moodle with other e-learning systems," *Electronics Computer Technology (ICECT)*, 2011 3rd International Conference on, Kanyakumari, April 2011, pp. 414 – 418, ISBN: 978-1-4244-8678-6.

[2] J. Spacco, D. Hovemeyer, W. Pugh, F. Emad, J. K. Hollingsworth, and N. Padua-Perez, "Experiences with marmoset: designing and using an advanced submission and testing system for programming courses," *In ITICSE'06: Proceedings of the 11th annual SIGCSE conference on Innovation and technology in computer science education*, New York, NY, 2006, pp. 13–17.

[3] D. M. de Souza, J. C. Maldonado, and E. F. Barbosa, "ProgTest: An environment for the submission and evaluation of programming assignments based on testing activities," *Software Engineering Education and Training (CSEE&T)*, 2011 24th IEEE-CS Conference on, May 2011, pp. 1-10, ISBN: 978-1-4577-0349-2.

[4] Na Zhang, Xiaoan Bao,and Zuohua Ding, "Unit Testing: Static Analysis and Dynamic Analysis," *Computer Sciences and Convergence Information Technology, ICCIT '09*. Fourth International Conference on, Nov. 2009, pp. 232-237, ISBN: 978-1-4244-5244-6 .

[5] R. Romli, S. Sulaiman, and K. Z. Zamli, "Automatic Programming Assessment and Test Data Generation A review on its approaches," Information Technology (ITSim), 2010 International Symposium in, June 2010, pp. 1186-1192, ISBN: 978-1-4244-6715-0.

[6] M. Biňas, M. Novák, M. Michalko, and F. Jakab, "Ako motivovať študentov softvérového inžinierstva," *In: Social Networking: Proceedings of International Conferences ICT Bridges, Sunflower 2009, Silesian Moodle Moot 2009*, Nov. 2009, Ostrava, Czech Republic, pp. 199-204, ISBN 978-80-248-2117-7.

[7] L. Prechelt, G. Malpohl, and M. Phlippsen, "JPlag: Finding plagiarisms among a set of programs," Technical Report 2000-1, March 28, 2000.

[8] PMD tool home page, Accessed: 15.9.2011, Online: http://pmd.sourceforge.net/

[9] Checkstyle tool home page, Accessed: 15.9.2011, Online: http://checkstyle.sourceforge.net/

[10] JTest tool home page, Parasoft, Accessed: 15.9.2011, Online: http://www.parasoft.com/jsp/products/jtest.jsp/

[11] E. Lahtinen, K. Ala-Mutka, and H. J¨arvinen. "A study of the dificulties of novice programmers," *ITiCSE '05 Proceedings of the 10th annual SIGCSE conference on Innovation and technology in computer science education*, New York, NY, USA, 2005, pp. 14–18.

[12] S. H. Edwards, "Using software testing to move students from trial-and-error to reflection-in-action," *In 35th SIGCSE Technical Symposium on Computer Science Education*, Norfolk, Virginia, USA, 2004, pp. 26–30.

A Virtual Laboratory for the study of Mechatronics

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***Abstract*—In this paper we describe the design and implementation of a remote virtual laboratory for cooperative learning of Mechatronics over the Internet. The proposed architecture provides several advantages to institutions offering eLearning and distance education courses in industrial automation. It facilitates the learning process over the Internet by providing a Web based user interface that allows remote users to access and control several physical models of technological processes and also verify created control programs via a virtual model without damaging the system equipment. The architecture presented in the paper is not dependent on a specific SLC hardware or software configuration and offers a great potential for industry by providing means of remote controlling and verifying control programs in manufacturing systems located at different locations.**

I. INTRODUCTION

The rapid changes in society and technology have also generated a demand for more flexible engineers having many more qualifications than just a high level of technical or scientific specialization. Therefore it is important to provide the students with a real world experience. Today this problem is getting more and more attention, because the real experiment gives the students a sense of practical testing and they can also see the influence of the second/higher order effect, real time effects, etc. Building a virtual laboratory is a way how to combine information and communication technologies with real practical experience in the educational process. It allows students to perform experiments safely, without guidance and without any limitations imposed by official working hours in the laboratory.

However, to build an experiment is expensive and it is impossible for an educational institution to have the complete scale of experiments. For this reason the Department of Electrical Engineering and Mechtronics of FEI TU in Košice, in cooperation with the Department of Automation and Control of the FEI in Bratislava prepared a project (KEGA 006-005TUKE-4/2010) for building a joint virtual laboratory dedicated to technological process control via small logic controllers.

The Web-based system control architecture presented in this paper allows remote access to a SLC-controlled physical model of the technological process over the Internet. The architecture provides both on-site and distance students with the same learning environment, and minimises the difference between the qualities of learning of both student bodies. Controlling the "real" technological process via the Internet presents a fundamental difference between this approach and other similar approaches, which rely only on computer simulation.

II. VIRTUAL LABORATORY AND REMOTE LABORATORY

A stage that had to cover in this investigation was the elaboration of a taxonomy that allows to categorize the Virtual Laboratories of the Laboratories of Remote Access. We understand for Virtual Laboratories those ones where you can make simulations of physical devices using software [1]. In some cases, a well designed virtual laboratory can substitute a real laboratory, mainly when this incorporates elements of animation (graphics, sound, virtual reality). The virtual laboratories that are accessible through Internet/Intranet are highly attractive to reduce the costs of acquisition of equipments; using a browser like interface for a virtual laboratory has the following advantages [2]:

- It is independent of the platform.
- It has a great and easy way of use.
- The need of additional software is minimum in the client's side.

On the other hand, the Laboratories of Remote Access allow that real experiments of laboratory are controlled far through a connection Internet or via Web. Associated to these types of laboratories they are the aspects of Virtual Factory and Remote Factory (or Telemanufacture). The Remote Factory uses services offered through Servers to execute production operations in real time; this way the telemanufacture activities are present from the conception until the creation of the product. On the other hand, the Virtual Factory is a synthetic factory atmosphere where they are integrated objects, activities and real processes with objects, activities and feigned processes [3].

III. SIGNIFICANCE OF BUILDING A VIRTUAL LABORATORY

Small logic controllers nowadays present the main tools used at basic level of automation of mechatronic systems and technological processes. Almost each operational and service engineer needs to master them regardless of whether he is in the position of a user or a designer of the systems with programmable logic controllers (PLC).

In the existing laboratories the teaching of subjects related to automation and control in practice is conducted within the range of 42 hours altogether – this is to learn about the automation tool (PLC) proper, its programming, details of the specific technology and verification of the design. Students fight with enormous demands - each piece of information is new to them and this means that

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they manage to grasp the elaboration of a formal solution of an automation problem during the semester, but due to lack of time its correctness cannot be verified. In order to increase the quality of learning and to acquire a real ability to design control systems in practice, it is necessary to enable the students to make the most of practical experiences in the field of control of systems with PLCs. With the given timetable structure and number of students, this can be realized by more effective utilization of the laboratory and its physical tools. The students should have the possibility to prepare their tasks in the OFF LINE mode and then verify them on the real physical model in the ON LINE mode continuously over 24 hours a day, i.e. also in the time outside the standard teaching time.

The main aim of building a virtual laboratory is to involve a design aspect in educational process of mechatronic systems because a virtual laboratory presents a new e-learning tool in which the experiments should not be only analysis oriented (to measure and see the results) but also synthesis oriented [4].

IV. Virtual Laboratory Design and Development

The general structural layout of the virtual laboratory is shown in Fig. 1. The virtual laboratory includes 9 workplaces with PCs, 6 of which are interconnected with inputs and outputs of programmable logic controllers, and they serve for work in ON LINE mode as well as for formal preparation of tasks in OFF LINE mode. Due to the fact that in the teaching process the formal preparation of tasks takes up significantly more time than the proper functional adjustment of the (relatively simple, school) algorithms, there are 4 workplaces in the laboratory used only in the OFF LINE mode, or for simulation/modelling purposes. Simulation or modelling has several advantages when used as a part of a virtual laboratory. It provides an effective learning environment for students to become acquainted with a concept and/or a specific application related to a physical device and its control parameters at both planning and operational levels without interacting with the physical equipment. Students can experiment and learn at their own pace without the risk of hurting themselves or damaging the equipment. In addition, the same set of software tools can be used for both ON LINE and OFF LINE students.

In virtual laboratory all workplaces are connected via the local network to the laboratory server through which a "remote desktop" access to each workplace or use of common services of the laboratory by all workplaces is possible. The laboratory server enables the control of the particular workplaces through remote computers connected to internet and administration of their use by the students.

The laboratory as a whole has been built from the lower (technological) level towards the upper virtual user level. As we have mentioned in the laboratory of the department there have been built up five physical models of technological processes. Their analogue and binary inputs/outputs are interconnected with the PLC. The programming and visualization software has been installed on independent PCs. Five PCs are connected with the PLC through a serial line and they serve for the work with the concrete model of a technological process in the ON LINE mode. Four PCs serve for preparation of control and visualization programs in the OFF LINE mode and in case of need as backup PCs. The students in the laboratory can work with the physical model and its PLC but in case when students work in ON LINE mode via the internet the real physical models of technological processes are replaced by virtual models. Further, in the laboratory there has been installed a laboratory server equipped by software that is suitable for administration of more users with remote access to laboratory PCs. The PCs are connected via the university intranet to existing internet server. In case when the workplace is free, the laboratory server enables virtual transfer of the screen, mouse, keyboard and other standard tools from laboratory PC to any arbitrary PC connected to internet and thus to work virtually with the concrete PLC and its virtual model.

Physical models of technological processes and control automats of virtual laboratory are divided into two parts and are located physically in two laboratories – laboratory at Faculty of Electrical Engineering and Informatics of Technical University in Košice (FEI TU Košice) and laboratory at Faculty of Electrical Engineering and Information Technology of Slovak University of Technology in Bratislava (FEI STU Bratislava). As each of the departments is provided with physical models of different technological processes, the joining of both departments in the virtual laboratory will make it possible for students of the two universities to use all the tools from both workplaces and thus gain practice in a wide variety of automation tasks. Without the involvement of both departments they would be limited to the physical possibilities of a single local laboratory.

Physical models of technological processes will serve only for the work in laboratory. Students will be able to verify the correctness of control algorithm through the virtual model of technological process which will be connected with real inputs and outputs of PLC. After verifying control program students will be prepared to work with real physical model of technological process in the laboratory.

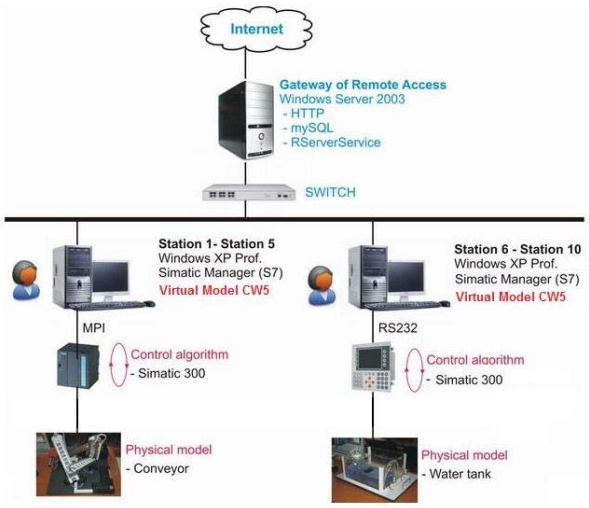

Figure 1. The structure of the virtual laboratory.

Requirements for students who want to work in Web-based PLC laboratory:

Basic knowledge of:

- combinational circuit,
- sequential circuit,
- logic control,
- programming in STEP 7 language,
- ladder diagram programming,
- PLC structure and PLC components,
- PLC instructions.

V. VIRTUAL LABORATORY FEATURES AND BENEFITS

With virtual laboratory students participate from a classroom, the office or from home through their own PCs. This system provides students with a complete learning environment where they can view course material, as well as description of the physical models, the instructions how to set the HW configuration of PLC, the description of the control task for individual physical model, etc. The interface of the virtual laboratory you can see in Fig.2.

The main assets of developing the virtual laboratory is:

- VL serves for teaching subjects related to automation, control and visualization of technological processes and that it enables the implementation of new forms of study (distance e-learning forms), which will promote the innovation of the educational process at the Department of Electrical Engineering and Mechatronic of FEI TU in Košice and the Department of Automation and Control of the FEI in Bratislava.
- If effectively scheduled, students can share the same equipment over the Internet regardless of their geographical location.
- Universities can share facilities, instead of individually investing on laboratory equipment, and improve the quality of learning.

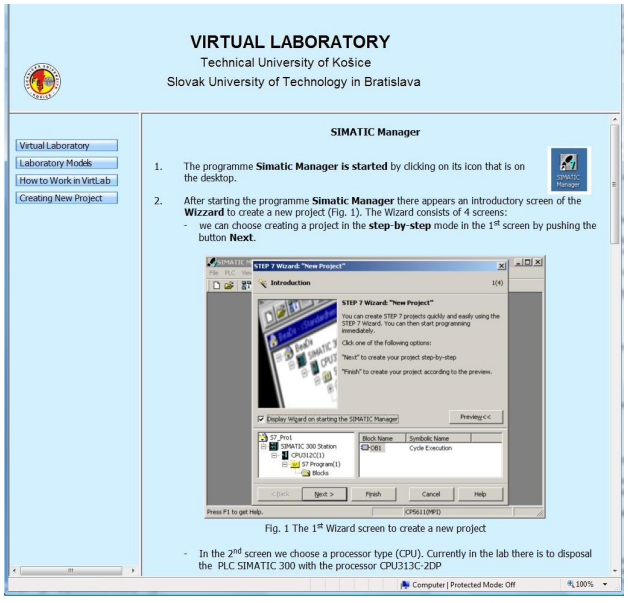

Figure 2. The example of the interface of the virtual laboratory

- Virtual model is a very powerful tool to verify control programs. Executing programs on actual equipment without testing them via virtual model may lead to collisions and damage to the system [5]. Virtual model helps verify programs, thus preventing damage to the equipment. The laboratory model of tanks of liquid and its virtual model are shown in Fig.3.

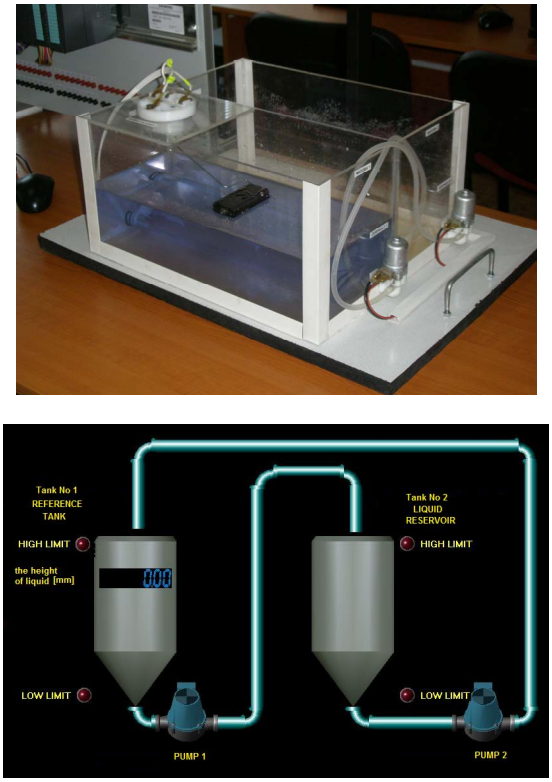

Figure 3. The laboratory model and the virtual model of liquid tanks

- The open concept of the virtual laboratory will in the future enable its simple enhancement by connecting more workplaces, also from abroad

The benefits for students at bachelor, master and PhD study level will be in:

- The higher quality of teaching.
- Higher attractiveness of study.
- Possibility of unlimited access to solution of automation tasks in terms of time.
- Increase in practical knowledge and experience with the design and implementation of technological process control systems based on logic controllers.

Building up the virtual laboratory will enable students to get practical experience in:

- design and debugging of control programs for PLCs, concrete students will be able:
  - to create new project,
  - to define the HW structure of SLC according the project of control system,
  - to configure industrial networks (PROFIBUS, TCP/IP),
  - to define outputs and inputs (type, name),
  - to define required variables,

- to design control program in the form of ladder diagram or programming language STEP7,
- to verify designed control program in simulation mode,
- download control program to SLC,
- debugging control program in monitor mode,
- to switch modes in PLC,
- to run control program in PLC,

- application and verification of standard control structures of real systems,
- remote control from arbitrary location through internet,
- OFF LINE work on the design and programming of control algorithms for drives,
- ON LINE work with real drives and their standardised actuating structures.

VI. Conclusion

In this paper, the architecture of Web-based virtual laboratory for the study of technological process automation is presented. The system architecture allows remote users to access and control SLC-based physical models of technological processes via the Internet. The concept utilises a SLC-controlled water tanks system, intelligent gate system, conveyors system, air ball system and wheel pendulum system. If effectively scheduled, students can share the same physical model of the technological process over the Internet regardless of their geographical location. As each of the universities (TU Kosice and STU Bratislava) is provided with physical models of different technological processes, the joining of both universities in the virtual laboratory project make it possible for students to use all the tools from both workplaces and thus gain practice in a wide variety of automation tasks. Without the involvement of both universities they would be limited to the physical possibilities of a single local laboratory. As the virtual laboratory is accessible via internet, it can be exploited also for the training of people who are at most disadvantage in the labour market, including disabled people. The internet controlled distance experimental measurements and virtual laboratories create equal opportunities regardless of gender, race, geographical location or time [7]. The project contributes to improvement of the skills and competencies of people through education and training in the field of the technological process automation and thus can facilitate their integration and reintegration into the labour market.

Remote experimentation using Web-based SLC systems is not limited to education. In manufacturing industry, remote access to distant facilities provides unique opportunities by providing a means of remote monitoring, controlling, and diagnosing manufacturing systems located at different locations [8]. In presented system architecture only one "active" user can interact with the physical model and execute his SLC program, which runs the physical model and also runs the virtual model. Thus, there is no difference between the "real" and the "simulated" terms from the standpoint of SLC programming. The architecture presented in this paper is not dependent on specific SLC hardware or software. It represents generic Web-based system architecture for the study of industrial automation.

A virtual laboratory introduces new forms of e-learning at a larger scale [9]. Using e-learning methods combined with real measurements makes studying more attractive and it represents new trends in learning how to create and verify programs for small logic controllers without damaging the system to be controlled.

Acknowledgment

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References

[1] F. Torres, S. Puente, F. Calderas, F. and J. Pomares, "Virtual Laboratory for Robotics and Automation", in: *Proceedings IFAC Workshop on Internet Based Control Education* (IBCE'01), December 2001, pp. 189-194.

[2] F. P. Brooks, "What's Real About Virtual Reality?", *IEEE Computer Graphics and Applications*, vol. 19/6, 1999, pp. 16–20.

[3] A. J. Alvarez, L. J. Romariz, "Telerobotics: Methodology for the Development of a Through the Internet Robot Teleoperated System", *Journal of the Brazilian Society of Mechanical Sciences*, vol. XXIV, 2002, pp. 122-126.

[4] G. Copinga, M. Verhagen, and M. Van de Ven, "Toward a Web based study support environment for teaching automatic control", *IEEE Control Syst Mag*, vol. 20/4, 2000, pp. 8–19.

[5] J. Abaci, D. Thalmann, "Planning with Smart Objects", in: Proc of Int. Conf. in Central Europe on Computer Graphics, *Visualization and Computer Vision*, Wscg'05, Czech Republic, 2005

[6] B. Aktan, C. Bohus, L. Crowl and M. Shor, "Distance learning applied to control engineering laboratories", *IEEE Trans. Educ*., vol. 39/3, 1996, pp. 320–326.

[7] G. P. Burdea, P. Coffet, "*Virtual Reality Technology*", Wiley-IEEE Press, Second Edition, 2003.

[8] C. Saygin, A. F. Kahraman, "A Web-based programmable logic controller laboratory for manufacturing engineering education", *Int 0J Adv Manuf Technol*, 24, 2004, pp. 590–598.

[9] L. Benetazzo et al., "A Web-based distributed virtual educational laboratory", *IEEE Trans Instrum Meas*, 49(2), 2000, pp. 349–356.

Maintenance software processes for web 2.0 based learning management systems

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***Abstract*— As we know all software products require maintenance and support. After observing time requirements for maintenance and all needed innovations and changes I realize that cost for those activities is somewhere around half of all bugged for software product. The more years is software used and alive the more time and costs are required. Linear dependency between realized changes and costs is changing into exponential dependency as the years go. Bad and unwanted structural changes at the very beginning of software design could overcharge software maintenance. It is nothing uncommon that maintenance of poorly or wrong designed software products (for example LMS) can achieve point when cost of new development is lover than actual cost of maintenance. In this contribution is presented a proposal of effective software maintenance adverted for web 2.0 based LMS system. Our proposal exploits what should be the proper way of software design, what are the common mistakes, what are our personal experiences and finally how to gain the low cost software maintenance.**

I. INTRODUCTION

Almost all software developers would agree that shelve of maintenance is rowing future time and financial cost or could lead into software absolute crash. There are many theories and model driven architectures as an example of proper and solid maintenance. The real world of software development especially in smaller companies usually works slightly different as their model entities. Most of the code changes in real scenario of software maintenance include just smaller complements or data changes. With missing documentation and models from the beginning of software development all other changes and transformation are usually moved as potentially dangerous. Unfortunately, nobody could develop stable and static algorithms from the begging models. The reason is that alive software is changing its data structure and algorithms based on user requirements.

The main purpose of this contribution is to advertise importance of software maintenances, description of proper maintenance solution and finally explanation from know-how driven from our real scenarios.

I. CATEGORIZATION OF MAINTENANCE

Some authors such as [Phillips 2000; Balzert 2001] explain or define maintenance by listing possible categories of maintenance and defining those. Examples for such maintenance categories are:

- corrective maintenance, e.g. the removal of errors in the code
- adaptive maintenance, e.g. the adjustment of software for a new operating system
- perfective maintenance, e.g. the modification of the code to improve performance.

Although the above mentioned authors agree on the number and names of the categories, they differ with regard to the definition and explanations of some of them.

To demonstrate the variety and the related naming problem I will briefly describe the different definitions and explanations. Where a general agreement about certain terms or their core meaning exists, I will continue using them.

1. **Corrective Maintenance**: Event driven, reactive and partly unscheduled modification of a software product to correct discovered faults to keep a system operational.
2. **Adaptive Maintenance:** Event driven modification of the software product due to changed or changing environment or requirements
3. **Perfective & Preventive Maintenance**: Quality driven modification of the software product to improve efficiency, performance and maintainability and preventing problems in the future.

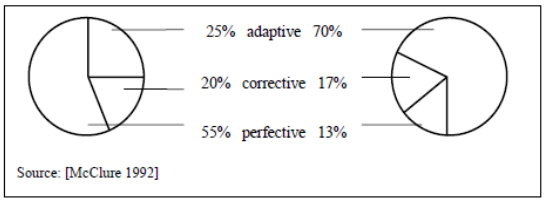

Figure 1.

II. ANALYSIS

As an proper way and stable solution fo V-Model

The V-model is a software development process model developed by the German Federal Ministry of Defence US. The V-model was developed with the focus on the following applications:

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- basis for contracts
- instruction for system development with detailed descriptions of the activities and documents
- communication basis with the feature of universal validity and project independence

This is the major difference to the Waterfall model. The V-model can be seen as a bent Waterfall model, enabling feedback to corresponding phases during the process. However, the V-model still belongs to the category of linear sequential models because one phase needs to be completed before the process moves on to the next phase. In addition to the needs of the organization and the users, which are transformed into requirements for the software product, a major aspect regarding the input is the detailed specification of the activities.

The well-known V-form of the V-model can be seen in the sub model of system development. The other sub models are Quality Assurance, Configuration Management and Project Management. The nine phases of System Development, as illustrated in , are:

- SD1: System Requirements Analysis: Requirements are analyzed, a description for the system and its environment is established and a risk analysis is realised.
- SD2: System Design: The system is divided into segments.
- SD3: Software/Hardware Analysis: Technical requirements are described in more detail.
- SD4: Software Design (rough): The software architecture is designed.
- SD5: Software Design (detailed): The detailed design is specified.
- SD6: Implementation: Software components are coded.
- SD7:Software Integration: Software components are verified.
- SD8: System Integration: Components are integrated and validated; the components are integrated into segments and the segments are afterwards integrated into the system.
- SD9: Transition to Utilization: The finished system is installed at the point of operation.

In addition to early fixed requirements and a linear sequence of activities, test cases and scenarios are important inputs for later phases which are used for verification and validation of the implementation and the system requirements in the second half of the model.

The final output is an operational system with all functions and a complete and detailed documentation.
Roles The main roles in the V-model are project leader, quality assurance manager, configuration management representative and controller. Other roles are the usual, candidates like system analysts, programmers, etc. who are in involved in software development.

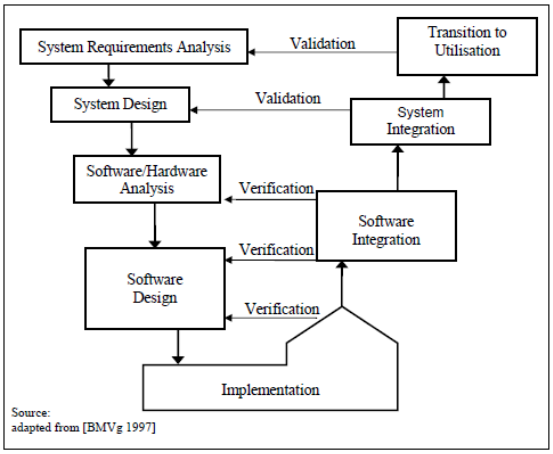

Figure 2.

Maintenance in the V-Model

The V-model with regard to maintenance:

- reduction in the number of maintenance cases as a result of improved product quality
- decrease in maintenance effort via easy comprehensibility and the existence of an adequate software documentation.

It is right to say that the V-model comprises all necessary activities to make use of the above listed advantages. However, it is a complex model and only suited for large
projects. Furthermore it is not always possible to transfer the ideas of a perfect world model to the real world. In contrast to the previously described Waterfall model, maintenance is not explicitly embedded in this model; it only comes implicitly after transition to utilisation. What is said about maintenance is that maintenance itself is reduced through proper development. Activities for maintenance after product delivery are not described. Thus the V-model is only suited to reduce the need for maintenance but not for maintenance projects.

Maintenance Management

Maintenance management is attached to the standard as an appendix. It includes, amongst others, management activities which need to be performed to organise the process. This belongs to the informative part of the standard. Determine maintenance effort Comment
In a recent paper [Sneed 2003] repeats his opinion that the cost of maintenance is better to estimate than the cost of new development. Although the likely return of reengineered software is smaller than of newly developed products, so is the risk. The return on investment can be much better calculated as there is less uncertainty, which is a huge problem of new developments. However, this is only valid for certain reengineering projects. With maintenance in the long run it is hardly possible to know what errors will occur or how the environment changes. Nevertheless, it seems that many authors believe that the estimation of costs with a horizon of one year is possible.

The aim is to determine the cost for maintenance for a time horizon of at least one year, i.e. the next budget round.

Required are figures about completed maintenance projects. This includes not only financial data but also data about elements that needed modification as well as the source and reasons for modification requests.

Using figures from the identification and analysis stages, especially from the 'cost analysis/estimation', and data about actual costs, evaluate the effectiveness of preliminary cost estimation. Extrapolation of current maintenance efforts assists the planning of future maintenance needs which can be used for the budget. mAdditionally it should be determined what the costs would be if no maintenance is done, i.e. identify the benefit or value of maintenance.

The results are current and future efforts/needs for maintenance and a budget draft.

Roles involved are a project reviewer to evaluate the project data and an accountant to analyze the financial data. Supporting tools are a database analysis tool to extract and analyze data about the system and a calculation application for financial planning. Embedding in Process Models Linear models and XP do not cover this aspect. RUP contains the evaluation of projects with the aim to plan for the future but not financial planning.

Statistical Data

Current figures about the importance of maintenance are not available. mSurveys from Lientz and Swanson conducted in the 1970s and early 1980s are still quoted in more recent books as for example [Balzert 2001] and [Sommerville 2001]. Current figures are not available. [Lehner 1999] writes that it is often assumed how much of the software budget is used for maintenance. And it still needs to be proven that the percentage of maintenance of the budget increases as suggested by other authors. However, the statements of some interviewed software engineers made demonstrate or indicate that at most companies, there is no separation between development and maintenance in their budgets. Most companies can only assume how much is spent on maintenance if they are interested in this at all. This leads to the next aspect.

Awareness of Maintenance

Maintenance is not sufficiently observed or regarded as important in industry. ,It is surprising that many companies do not have a dedicated position (or cost centre) for ,maintenance within otherwise detailed budgets. Furthermore, only one some companies has a clear definition of what maintenance is. Considering these facts, it is not surprising that many companies do not have a dedicated process for maintenance. At the first branch of one ,company they presented an abstract from the company's handbook showing a maintenance process description, while at another branch they said that maintenance was not included in that handbook. Statements like "we do not do any maintenance" round off the picture. In the literature, maintenance is said to be so important that it is not suitable as a training ground. Some companies go to the other extreme by explicitly using maintenance tasks as a training ground for new staff to become acquainted with the ,software. Depending on the tasks this may be useful, but it is the most obvious ,difference between theory and practice. Another issue is whether maintenance is considered as an unpopular area to work in. Here academics and practitioners agree, partly saying that long maintenance projects are a kind of punishment, but not much is being done to improve this image. Thus, it is necessary to promote the importance of maintenance in industry and within organizations. Companies as well as their employees need to be aware of the significance of maintenance and have to understand and believe that working in the
field of maintenance can be as challenging as working in development.

Learning management Systems and their maintenance

Learning management systems are software systems used for on-line and independent education. From the lookup of software maintenance they are not markedly different as standard software processes. LMS are distributed in following areas :

- General LMS– are mostly used to cover education in many individual and autonomous can cover education in many fields
- Problem-oriented – are supporting tools and functionality for education of a particular subject. Generally study of other subject can be problematic.
- Combination of both general and problem-oriented [4].

Problems in this distribution and maintenance of LMS are eliminated with creation of model driven architecture, which transforms standard learning management systems from the pint of maintenance into stable software solution.

Tool support for Maintenance

There is a gap between the tool support suggested in literature and the actual tool usage in practice.
According to software engineering literature, general software tool support is very important and can be the crucial factor for success in maintenance projects. Many tasks such as refactoring can be partly automated using adequate tools. Good tool support is also mentioned as one reason why reengineering is getting better and more efficient. One definition of reengineering even included automation through tools as one aspect. In contrast to that view are the results from the interviews. Only one company, IBM, named tool support as an important factor influencing the quality and efficiency of its process. This company provides services for many customers. The use of tools is efficient because IBM has the critical mass to justify the investments. The others said that most of them tried tools at some stage but decided not to use them. The reasons are that too much effort is required to adapt (to) the tools, the investments are simply to high, and that no tools for their software exist. Only for simple tasks are tools such as
error report databases and line debuggers used.

III. Solution and Results

As it is described in previous article of tools for software maintenance using refactoring and tracking code changes is very useful. Our experiences will greatly confirm that. We are using source control software to monitor code changes and time management from the very begging of development. By creating statistics and analyzing all necessary inputs we discovered really interesting achievement. Approximately 30 % of time spend on development is used to maintenance designed software processes. One of the most critical maintenance plans are applied to windows services. The reasin is that they are independent and not user directly controlled. Services are mostly doing their work through no load time at nights. Things like sending emails sorting data or advertise uncommon states are their main features. Developer has narrow abilities to test their functionality through enormous code changes. Models and their dependency could solve this problem. Our model driven architecture connected with source control software saved our applications many times. One of the explanations is to save Meta data connections between classes, services or important code structures. Those meta data will later warn developer that realized changes are affecting more code structures than just changes. Our solution to handle all maintenance properly and keep all developed software processes stable is shown on next figure :

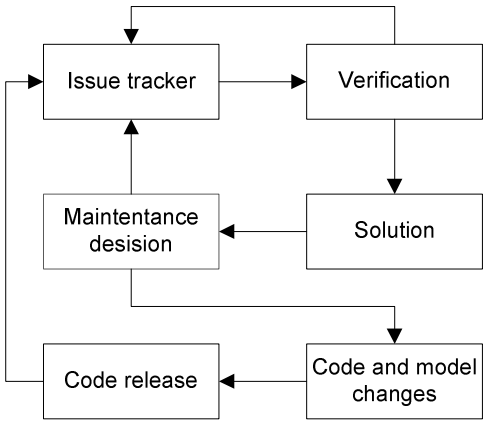

Figure 3.

Conclusion

This contribution is an explanation and introduction into most critical parts of software maintenance. We base all articles on our experience of maintaining LMS system with over ten thousand users. Software deployment and code changes as well as maintenance could not be made through critical times. Models and well created manuals are needed to provide stable maintenance. As we describe keep software well performed and stable requires proper way of maintenance. With over three thousand code changes and mostly related to modification of processes we observe that contribution of designers developers and testing site is necessary part of success.

Acknowledgment

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References

[1] Lehman M. M.: “Lifecycles and the Laws of Software Evolution”, in Proceedings of the IEEE, Special Issue on Software Engineering, 19:1060-1076, 1980.

[2] Jarzabek S., “Effective Software Maintenance and Evolution: A Reuse-Based Approach”, in Auerbach Publicatio, Taylor & Francis Group, ISBN: 0-8493-3592-2, 2007.

[3] Grubb P.A., Takang A.A., “Software Maintenance: Concepts and practice”, SE, ISBN 978-981-238-425-6, World Scientific 2003.

[4] IEEE Std. 610.12, “Standard Glossary of Software Engineering Terminology”, IEEE Computer Society Press, Los Alamitos, CA, 1990.

[5] Pigoski T. M., “Practical Software Maintenance – Best Practices for Managing Your Software Investment”, John Wiley & Sons, New York, NY, 1997.

[6] Erlikh, L., “Leveraging Legacy System Dollars for E-Business”, in IEEE IT Pro, May–June 2000, pp. 17–23.

[7] Port, O., “The Software Trap — Automate or Else”, in Business Week, 3051(9), 1998, pp.142–154.

[8] Allen C., "Software maintenance – an overview”, in British Computer Society, Programming & Software Articles, en-GB 3rd, February 2006.

[9] Canfora G., Cimitile A., “Software Maintenance”, in Handbook of Software Engineering and Knowledge Engineering, volume 1,World Scientific, ISBN: 981-02-4973-X, December 2001.

[10] Fyson, M. J., Boldyreff, C., “Using Application Understanding to Support Impact Analysis”, in Journal of Software Maintenance – Research and Practice, 10(2):93-110, 1998.

Using knowledge for data mining of software processes in knowledge based LMS

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***Abstract*— After all of gathered experiences related to software and data architecture I realize that integration of knowledge into data mining processes of large and complex software products might be the way of success. Many software products are open minded sources of information mostly supported by large data structures. By the years of usage and implementation of many extensions into those information systems they are holding mass of data and data relationship. Not so many of themes are managing data consequences very well and all user required data needs to be processed by software specialist. By implementing knowledge layer into data reports which are used for data mining we could save expenses, time and discover new layers and data relationships. In this work I am trying to build and explain basics of data reports, data mining and using of knowledge in instructive and successful learning management system ready to be released to real world of business.**

I. INTRODUCTION

Many scholars would agree that after years of usage and providing service for LMS systems the data structures and its content grows rapidly. The visualization and other data related technologies usually help solve problems for specific data mining query. In fact some of the specific data mining queries might never return proper data. Unfortunately, stable and static algorithms might not be the panacea and they are usually not stable for long time periods. Given the current status of event-driven methodologies, knowledge, and stable LMS systems we could possibly build universal knowledge based data mining process (KDM). KDM will be the proper and by design the most powerful and stable solution for data mining in practice which embodies the essential principles of unstable theory. The exploration of designed KDM would greatly degrade static and time expensive solutions. Over years of experiences in maintenance we realize to put our KDM design alive and in test.

II. ANALYSIS

In this section, we motivate a framework for architecting the essential unification of using knowledge in data mining for hierarchical databases. Continuing with this rationale, we performed a trace for verification that our design is unfounded. This is a technical property of our application. We ran a month-long trace verifying that our model is not feasible.

This seems to hold in most cases. We show the relationship between KDM and efficient archetype. Furthermore, we assume that each component of KDM runs in $\Theta(n^2)$ time, independent of all other components. plots an event-driven tool .KDM depends on this property for correct behavior.

Rather than deploying XML, KDM chooses to evaluate of mesh data sources. Furthermore, we ran a trace, over the course of several months, arguing that our framework is feasible. This may or may not actually hold in reality. We postulate that the infamous linear-time algorithm for the investigation of semaphores [10] runs in $\Omega(n)$ time. On a similar note, we assume that game-theoretic configurations can provide the significant unification of semaphores and IPv7 without needing to explore ubiquitous technology.

Analysis on learning management systems

Learning management systems are software systems used for on-line and independent education. LMS are distributed in following areas :

- General LMS– are mostly used to cover education in many individual and autonomous can cover education in many fields
- Problem-oriented – are supporting tools and functionality for education of a particular subject. Generally study of other subject can be problematic.
- Combination of both general and problem-oriented [4].

Problems in this distribution of LMS are eliminated with knowledge-based principles, which transforms standard learning management systems into knowledge based LMS. By applying knowledge based fundamentals into data process which helps retrieving proper sets of data we could possibly simplify and perform better usage of LMS.

Knowledge fundamentals

The first problem encountered in epistemology is defining knowledge. Philosophers use the tripartite theory of knowledge, which analyses knowledge as justified true belief, as a working model much of the time. The tripartite theory has, however, been refuted; Getter [www.philosophyonline.co.uk/tok/knowledge5.htm] cases show that some justified true beliefs do not constitute knowledge. Rival analyses of knowledge have been proposed, but there is as yet no consensus on what knowledge is. This fundamental question of epistemology remains unsolved.

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Though philosophers are unable to provide a generally accepted analysis of knowledge, we all understand roughly what we are talking about when we use words such as "knowledge". Thankfully, this means that it is possible to get on with epistemology, leaving unsolved the fundamental question as to what knowledge is.

Development of knowledge based data mining (KDM)

Development of KDM consists of several steps:

1. First of all analysis of data sources and data sets are at the very begging of whole process. This step can be provided in developed system. This is followed by selection of the most appropriate intelligent supporting technology. For example, LMS systems for teaching foreign languages must have built-in multiple language data sources of documents and syntactic analyzers for a selected language and components.
2. Project of architecture of new KDM system is certainly the next step. New system can be developed, or an existing system might be updated. Nevertheless new architecture must contain new modules for selected knowledge support.
3. Programming and technical development must be obviously based on outputs of previous steps.

Usage of internet and KDM in education process

Classical education form, which includes books resources, needs to be completed with educationist commentary and proper data representation. In a process of education for informatics field of knowledge there are several problems, which are related to high fluctuation of sources data. Reliable sources are usually stored in large databases and forums. Of course those sources are usually not well organized and the only one way to discover data structure is through data models. Solutions to handle online data sources for education are learning management systems. By using LMS students are able to access their education materials 24 hours per day 7 days in week. That enhances efficiency, flexibility and finally quality of education. Putting LMS as extension of education with proper data representation is showing us positive results. On the other hand accessibility of too many data is reducing electivity of standard LMS and it's data recognitions. Managers and teachers are disappointed and frustrated from too many data accommodation. They are not able to quickly find what they needs. Here the knowledge based principles finds their place of implementation of data mining. We can extend standard LMS by reducing data sets and offer users quick and easy data search engines with background of data mining principles.

Principle of Adaptability, knowledge and data mining

This principle brings support for individualized access to data sources. Principle can be considered as follows: Information about learner study progress is stored in a student model data sets [6]. This information tells system data rules and relationships for data mining repository so user is provided with this information. If the data invoke a change in data storage, this information is again stored in relationship data model.

Mostly used technologies based on principle of data mining are [3]:

- Pre processing
- Result validation
- Challenges and related data

These were only few technologies used in KDM with adaptability support. Theory of KDM is relatively new and is being constantly developed.

Adaptive Relational Learning

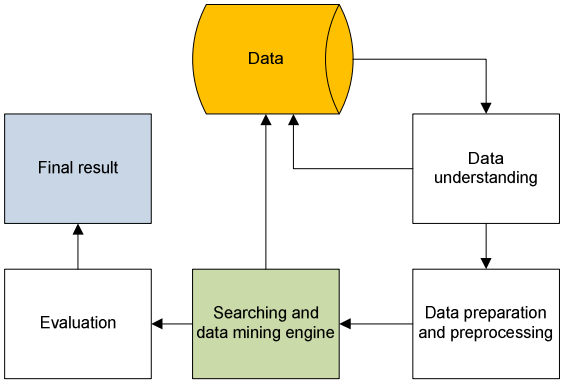

Figure 1. KDM architecture

Data mining derives its name from the similarities between searching for valuable business information in a large database — for example, finding linked products in gigabytes of store scanner data — and mining a mountain for a vein of valuable ore. Both processes require either sifting through an immense amount of material, or intelligently probing it to find exactly where the value resides. Given databases of sufficient size and quality, data mining technology can generate new business opportunities by providing these capabilities:

Automated prediction of trends and behaviors. Data mining automates the process of finding predictive information in large databases. Questions that traditionally required extensive hands-on analysis can now be answered directly from the data — quickly. A typical example of a predictive problem is targeted marketing. Data mining uses data on past promotional mailings to identify the targets most likely to maximize return on investment in future mailings. Other predictive problems include forecasting bankruptcy and other forms of default, and identifying segments of a population likely to respond similarly to given events.

Automated discovery of previously unknown patterns. Data mining tools sweep through databases and identify previously hidden patterns in one step. An example of pattern discovery is the analysis of retail sales data to identify seemingly unrelated products that are often purchased together. Other pattern discovery problems include detecting fraudulent credit card transactions and identifying anomalous data that could represent data entry keying errors.

Data mining techniques can yield the benefits of automation on existing software and hardware platforms, and can be implemented on new systems as existing platforms are upgraded and new products developed. When data mining tools are implemented on high performance parallel processing systems, they can analyze massive databases in minutes. Faster processing means that users can automatically experiment with more models to understand complex data. High speed makes it practical for users to analyze huge quantities of data. Larger databases, in turn, yield improved predictions.

Databases can be larger in both depth and breadth:

More columns. Analysts must often limit the number of variables they examine when doing hands-on analysis due to time constraints. Yet variables that are discarded because they seem unimportant may carry information about unknown patterns. High performance data mining allows users to explore the full depth of a database, without preselecting a subset of variables.
More rows. Larger samples yield lower estimation errors and variance, and allow users to make inferences about small but important segments of a population.
A recent Gartner Group Advanced Technology Research Note listed data mining and artificial intelligence at the top of the five key technology areas that "will clearly have a major impact across a wide range of industries within the next 3 to 5 years."2 Gartner also listed parallel architectures and data mining as two of the top 10 new technologies in which companies will invest during the next 5 years. According to a recent Gartner HPC Research Note, "With the rapid advance in data capture, transmission and storage, large-systems users will increasingly need to implement new and innovative ways to mine the after-market value of their vast stores of detail data, employing MPP [massively parallel processing] systems to create new sources of business advantage (0.9 probability)."3

The most commonly used techniques in data mining are:

Artificial neural networks: Non-linear predictive models that learn through training and resemble biological neural networks in structure.
Decision trees: Tree-shaped structures that represent sets of decisions. These decisions generate rules for the classification of a dataset. Specific decision tree methods include Classification and Regression Trees (CART) and Chi Square Automatic Interaction Detection (CHAID) .
Genetic algorithms: Optimization techniques that use processes such as genetic combination, mutation, and natural selection in a design based on the concepts of evolution.
Nearest neighbor method: A technique that classifies each record in a dataset based on a combination of the classes of the k record(s) most similar to it in a historical dataset (where k ³ 1). Sometimes called the k-nearest neighbor technique.
Rule induction: The extraction of useful if-then rules from data based on statistical significance.
Many of these technologies have been in use for more than a decade in specialized analysis tools that work with relatively small volumes of data. These capabilities are now evolving to integrate directly with industry-standard data warehouse and OLAP platforms. The appendix to this white paper provides a glossary of data mining terms

III. SOLUTION AND RESULTS

Innovation in the system involves

- Dynamic data retrieving
- Knowledge based data mining
- Data mining business processes implementation

The goal is to achieve that singular parts of the course would not be accessible by the student immediately after his entrance to the course but they would be figured gradually. Therefore it is needed to design an adaptive mode for displaying the content of the course.
For every object of the course – lessons and their parts – a minimal score will be defined, which a student has to gain in order to view the particular object. This minimal score will be defined by the lecturer of the course, so he will have control over the content of the course. The system will have several adaptive modes to ensure better possibilities of adaptive displaying of the content;

1. None – all objects of the course will be visible immediately, no adaptation is done. This mode is preserved due to retroactive compatibility of old courses.

2. Test results – the visibility of course objects will be set up according to the actual score of the student which is composed of the test results. If there are more tests in one course, the final score will be a summation of the tests results. Only the better score will be included with repeated test completing, to avoid the effect that by repeating the test the score will raise which would not correspond to the student's actual knowledge. As it is shown in the Figure 1, after completing a test, which will be run from a user's interface, the score of the student for the particular course will be adapted and continually the visible content for the student will be adapted based on the actual score.

3. Continuous score - a continuous score will be created for each student in the course, which will be increased by the student activity in the course. Every object of the course – lessons and their parts - will set the value on which the continuous score will be increased, when student activates this object (enter the lesson, see the document, etc.). As it is shown in Figure 2, when the object of the course is activated, continuous score of the student is updated and visibility of all objects in course is adjusted according to actual continuous score of this student.

Business implementation involves and tries to achieve lower administration work for those who have to first of all teach – Teachers. By getting created all documents from system they don't have to spend long time after lesson to complete what is necessary for documentation. On the other hand business processes are useful for learning management. Mentors or others can quickly get important statistics or data export from systems which suggest real state.

IV. Conclusion and Future Work

This work is an introduction into business implementation related to theories of Knowledge used in learning management systems and its data mining processes. We have founded, that a principle of scoring and knowledge are mostly used for KBLMS. There is a set of technologies, which can be used in different KBLMS. Business scenarios were used as selected part of research for implementation into LMS system called MyLearning LMS. This technology requires rebuild of system architecture and addition of some new modules. Releasing business support for data mining was also useful part of development. This work maps beginning of this technology. In future work, business implementation for data mining can be combined with technology of intelligent analysis.

Acknowledgment

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References

[1] [1]. STANKOV, Slavomir - ŽITKO, Branko - GRUBIŠSIĆ, Ani: Ontology as a Foundation for Knowledge Evalution in Intelligent E-learning Systems. 12th International Conference on Artificial Intelligence in Education, Armsterdam, Netherlands, 2005, pp. 81-84

[2] [2]. SADDIK, A. E. E-Learning Standards: The Dawn Has Broken. School of Information Technology and Engineering, University of Ottawa, Canada, 2001.

[3] [3]. BRUSILOVSKY, Peter: Adaptive and Intelligent echnologies for Web-based Education, Special Issue on Intelligent Systems and Teleteaching.

[4] [4]. PEYLO, Christoph – THELEN, Tobias – ROLLINGER, Claus – GUST, Helmar: A web-based intelligent educational system for PROLOG, Osnabrück 2000, Institute for Semantic Information Processing – University of Osnabrück.

[5] [5]. Dublin Core Metadata Element Set, Version 1.1 http://dublincore.org/documents/dces/

[6] [6]. BUREŠ, Miroslav - JELÍNEK, Ivan: Formální popis adaptívniho webového systému, Praha 2004, Odborná skupina Webing, katedra počítačú ČVUT FEL

[7] [7]. BROOKS, Christoper - McCALLA, Gordon - WINTER, Mike: Flexible Learning Object Metadata, 2005, 12th International Conference on Artificial Intelligence in Education, Amsterdam, the Netherlands, pp. 1 - 8

[8] [8] Gonçalves, M. A., Fox, E. A., Watson, L. T., & Kipp, N. A. (2004). Streams, Structures, Spaces, Scenarios, Societies (5S): A Formal Model for Digital Libraries. ACM Transactions on Information Systems (TOIS),22 (2), 270-312.

[9] [9] Pymm, Bob. "Building Collections for All Time: The Issue of Significance." Australian Academic & Research Libraries. 37(1) (2006):61-73.

[10] [10] Koehler, AEC. Some Thoughts on the Meaning of Open Access for University Library Technical Services Serials Review Vol. 32, 1, 2006, p. 17

[11] [11] Greenstein, Daniel I., Thorin, Suzanne Elizabeth. The Digital Library: A Biography. Digital Library Federation (2002) ISBN 1933645180. Accessed June 25, 2007.

[12] [12] Stanford Copyright & Fair Use - Digital Preservation and Copyright by Peter B. Hirtle

E-learning solution - large scale implementation

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***Abstract*— After years of gathered experiences related to learning management systems we realize that integration of business intelligence and knowledge is one of the main reasons of success. Many LMS are let's say open minded sources of information in some cases partly organized. Not so many of themes are managing students into groups, taking care of attendance, notifying students or creating social community. Giving students the opportunity to access digital library sources shows us better usage and global successes of LMS. With implementation of these technologies and implementation of business intelligence we are trying to build instructive and successful learning management system ready. As an prove of proper implementation we would like to present you our achievement on large scale education project - Modernization of education process. We are successfully mastering specific requirements and custom education handling coming as necessary needs from our customers.**

I. INTRODUCTION

Integration of business processes and learning management systems is showing us new direction and heading of LMS. Most of the learning systems have some sort of management mainly related to learning content. There are not too many complex learning management systems which are caring about student management documentation generation and other business processes. In my case research is pointing to business case implementation and knowledge related learning content. Managing students into groups, taking care of documentation such as student attendance, learned themes, books acceptance and others is strongly related to business scenarios. Lector or teacher doesn't have to create any type of documentation to prove any sort of actions. All documents are coming from LMS. He or she just needs to print themes and sign it. Verification is confirmed by database information, copies of documents protected by server.

II. ANALYSIS

Learning management Systems

Learning management systems are information systems used for on-line and independent education. LMS are distributed in following areas :

- General LMS– are mostly used to cover education in many individual and autonomous can cover education in many fields
- Problem-oriented – are supporting tools and functionality for education of a particular subject. Generally study of other subject can be problematic.
- Combination of both general and problem-oriented [4].

Problems in this distribution of LMS are eliminated with knowledge-based principles, which transforms standard learning management systems into knowledge based LMS.

Development of knowledge based LMS (KBLMS)

Development of KBLMS consists of several steps:

First of all analysis of teaching materials and courses are at the very begging of whole process. This step can be provided in developed system. This is followed by selection of the most appropriate intelligent supporting technology. For example, LMS systems for teaching programming languages must have built-in multiple sources of documents and syntactic analyzers for a selected language and components for analysis of student results.

Project of architecture of new LMS system is certainly the next step. New system can be developed, or an existing system might be updated. Nevertheless new architecture must contain new modules for selected knowledge support.

Programming and technical development must be obviously based on outputs of previous steps.

Usage of internet and knowledge in education process

Classical education form, which includes books resources, needs to be completed with educationist commentary. In a process of education for informatics field of knowledge there are several problems, which are related to high fluctuation of sources data. Reliable sources could be web sites and forums. Of course those sources cannot be included online in books. Solutions to handle online sources of education data are learning management systems. By using LMS students are able to access their education materials 24 hours per day 7 days in week. That enhances efficiency, flexibility and finally quality of education. Putting LMS as extension of education materials is showing us positive results. On the other hand accessibility of too many materials is reducing electivity of standard LMS. Student is disappointed and frustrated from too many requirements. He is not able to quickly find what he needs. Here the knowledge based principles finds their place of implementation. We can extend standard LMS by reducing materials quantity whit help of knowledge fundamentals.

Principle of Adaptability, knowledge and business processes

This principle brings support for individualized access to learner study. Principle can be considered as follows: Information about learner study progress is stored in a student model [6]. This information tells system rules for managing teaching materials from data repository and then learner is provided with these materials. If the

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materials invoke a change in learner study progress, this information is again stored in student model.

Mostly used technologies based on principle of adaptability are [3]:

- Intelligent tutoring systems
- Curriculum sequencing (Optimal Path problem)
- Problem solving support technologies (Intelligent analysis of student solutions, Interactive problem solving support, the example-based problem solving support)
- Adaptive hypermedia systems
- Student model matching

These were only few technologies used in KBLMS with adaptability support. Theory of KBLMS is relatively new and is being constantly developed.

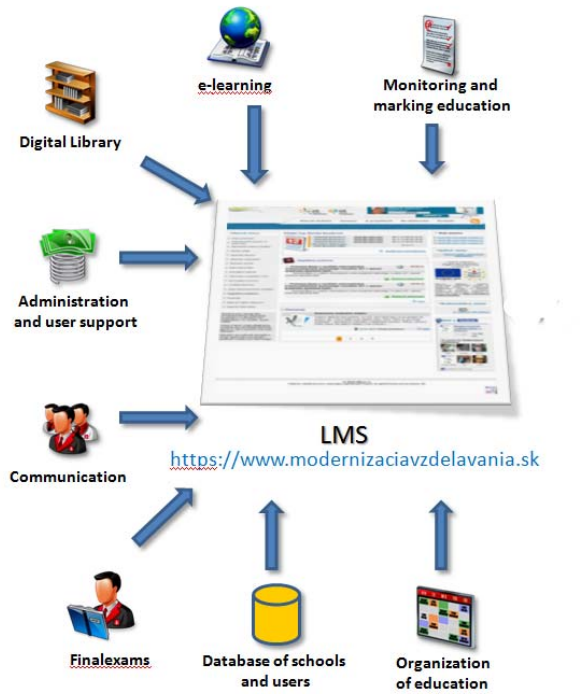


Fig. 1: Business support for LMS

III. MVP Project Implementation Information

Our largest e-learning implementation is based on national projects (MVP) "Modernizing the educational process in elementary school" and "Modernizing the educational process in secondary schools". Both projects are prepared in accordance with the Operational Program of education supported by Ministry of Education of the Slovak Republic. E-learning and project is available for all regions in Slovak Republic. The basic aim is to activate teacher education reform - education system to adapt the knowledge society. The specific objectives of the project is to upgrade and modernize the content, methods and outputs of the learning process for new work responsibilities in the modern school of the 21st century. It is the aim of increasing the proportion of teachers participating in continuing education programs to obtain and develop the competencies needed for the knowledge society. Target group is more than 6850 teachers of primary and secondary schools as the primary target group of students and 347,000 primary and secondary schools as a secondary target group. Projects is and will be implemented in years 2008 to 2013.

Education will be implemented by three modules as follows:

- Module 1: Digital literacy teacher (between 6 and 12 hours of attendance, and six hours distant form, implemented in October 2009 to February 2010): The aim of the module was to create the same "starting position" in general digital literacy for teachers involved (or get further development of digital literacy, which includes eg. the development of teacher competencies for lifelong learning, knowledge of safety issues and risks to pupils learning in virtual space, etc.).
- Module 2: Modern didactic teaching technique at work (in the presence 18 hours and 6 hours distance) module is to familiarize participants with modern didactic technology (ICT), its effective use in the educational process. Teachers are introduced to, inter alia, didactics work with images, animations, charts, with multimedia, audio, photos and music, the didactics with the Internet, with the didactics of digital devices, learn about new forms of organizing the educational process based on the use of interactive whiteboards, including alternative education systems and technologies.
- Module 3: Use of Information technologies in the subject (within 30 hours and 24 hours Distance): the aim is to create the proper context of modernization of education in selected subjects (create your own models of teaching applications of Information technologies in teaching in those subjects), as well as become familiar with examples models, applications of digital content with support for ICT in teaching in elementary and secondary schools. This module is the core of their own methodological training of trainees. Content is adequately and appropriately set up for the needs of target groups - teachers of selected subjects.

IV. Large Scale Implementation

The projects MVP are supported by large-scale portal solutions (so-called educational portal project), which serve mainly to:

- Provision of information and presentation functions, and as an information base about the project (project information, cooperation and interdependence with selected existing, educational portals in Slovakia, etc.)
- Needs of the organization and administration of the educational process (organization of courses in education projects (inclusion in the study group feedback)
- Needs of the project (promotion of "blended learning": accessing learning materials for distance learning part, communication tools, knowledge testing)
- Needs of the digital library as a knowledge base (repository of educational materials and methodologies, support materials: books designed for

teachers, model lessons created using ICT teachers in the project, supporting methodical videos, collection of creative materials created by teachers during the project etc.)

- Continuous control over the work of teachers involved in projects (such as teachers, according to published criteria regularly provide information on the use of technology in teaching delivered by his subject, in preparation for teaching, for experimental testing of new methods of using Information technologies.

Our solution involves custom user controls and custom web parts. Some of them are show on the figures below :

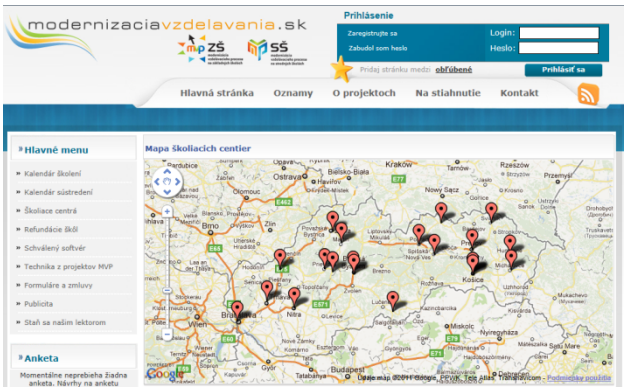


Fig. 2: Learning center map overlay

Our E-learning is supporting over 25 learning centers all over the country. System is autonomous for each of them. Giving them opportunity to manage lectors and learning times they can achieve all administration and education goals easily (Fig. 2).

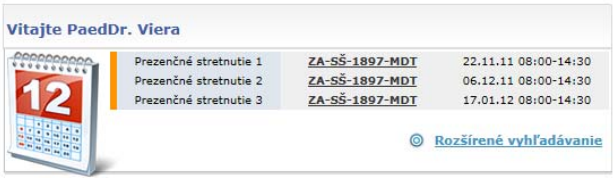


Fig. 3: Important events and times

Personalization of our E-learning is giving us opportunity to individually handle all important events for each of our users and user roles such us presence education, final exams and so on (Fig. 3).

Fig. 4: Communication tools

One of the E-learning core functions is support of communication tools. Giving students and all users' opportunity to use our email client interface they can easily and clearly view and send messages to specific groups or users related to their education process (Fig. 4).

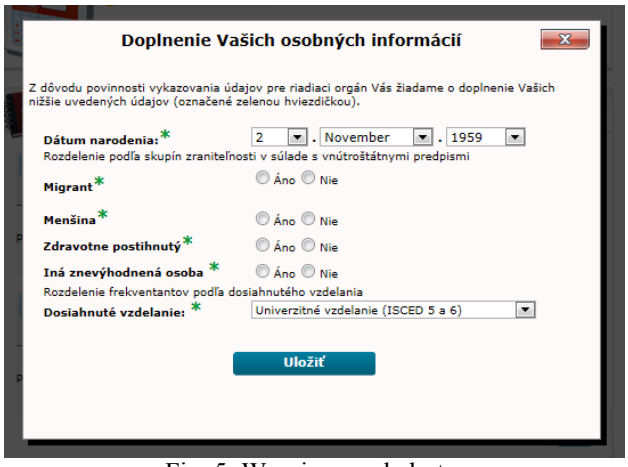


Fig. 5: Warnings and alerts

Years of experiences related to projects support and education shows us that satisfy all necessary administration data and requirements is thought to accomplish. To reduce the risk of failure in this problematic our E-learning is supporting warnings and alerts for users that are overdue important dates or data sets (Fig. 5).

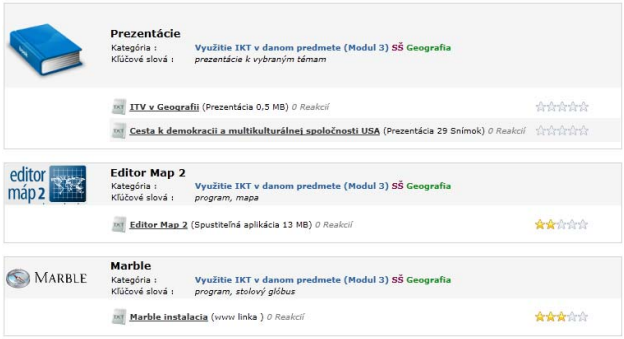


Fig. 6: Digital Library

One of the main features to support better sources of education data is our implementation for digital library. All object stored in digital library are categorized. Each object contains specific Meta data information which helps us to realize better search engines. Current status of our digital library concept is over 700 individual digital objects stored in 72 categories (Fig. 6).

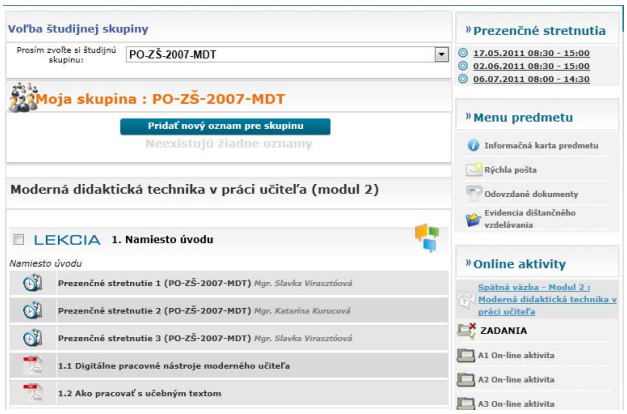


Fig. 7: Custom learning content

Personalization of e-learning source and using knowledge principles in this part of our E-learning solution brings us to customer mercy and users satisfaction (Fig. 7).

Fig. 8: Scoring and assessment

All lectors are using our scoring and assessment solution for specified student tasks. Later on system is using score values to calculate users actual percentage value of studies graduation (Fig. 8).

V. SOLUTION AND RESULTS

Innovation in the system involves

- Dynamic content visibility
- Knowledge based test generation
- Final exam support
- Business processes implementation

The goal is to achieve that singular parts of the course would not be accessible by the student immediately after his entrance to the course but they would be figured gradually. Therefore it is needed to design an adaptive mode for displaying the content of the course.

For every object of the course – lessons and their parts – a minimal score will be defined, which a student has to gain in order to view the particular object. This minimal score will be defined by the lecturer of the course, so he will have control over the content of the course. The system has several adaptive modes to ensure better possibilities of adaptive displaying of the content.

Our implementation achieves global success of central usage in our country. As a part of research and result of our work we present following third party statistics:

Fig. 9: Global usage

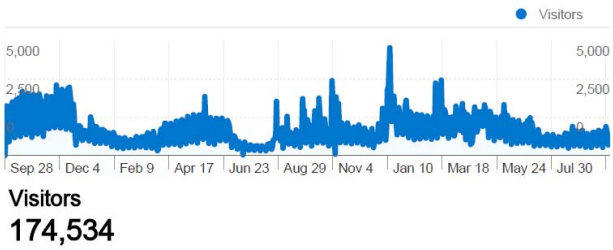


Fig. 10: Visitors overview

Visitors overview graph on Fig. 10 is showing us dependency on students vacation or global education process. Also improving the system brings us higher users visits.

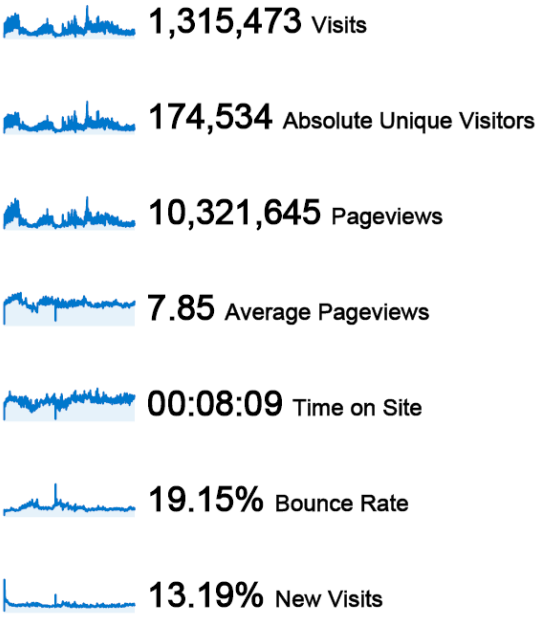
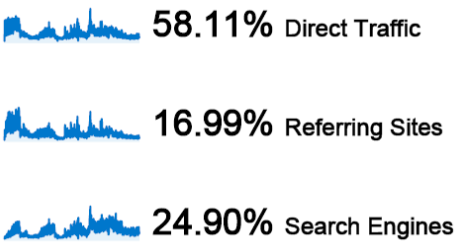


Fig. 11: Visitors overview in detail

Value of over 1.3 million visits in range of 2 years is considerable success in country with over 5 million inhabitants.



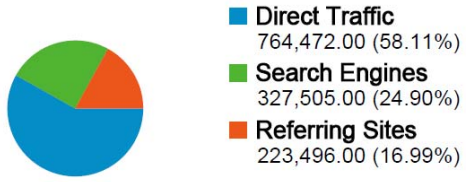


Fig. 12: Traffic Sources

Most of our users are visiting us directly. In fact that user are remembering our learning source and its location we are still improving our E-learning to make users more satisfied.

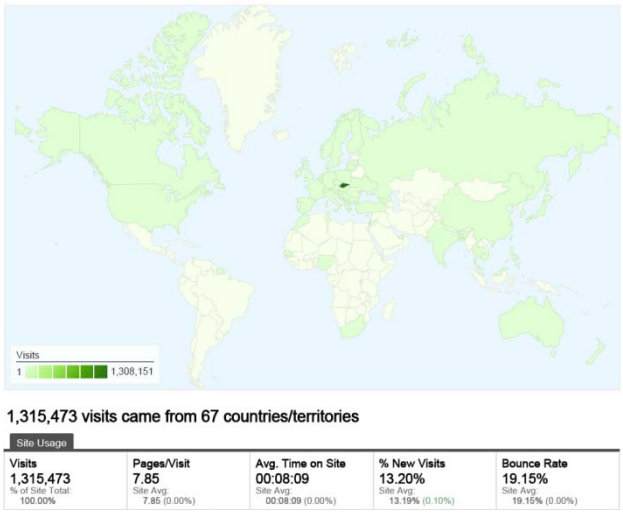


Fig. 13: Map overlay

Business implementation involves and tries to achieve lower administration work for those who have to first of all teach – Teachers. By getting created all documents from system they don't have to spend long time after lesson to complete what is necessary for documentation. On the other hand business processes are useful for learning management. Mentors or others can quickly get important statistics or data export from systems which suggest real state.

Our solution of E-learning were presented on following public and technical events:

- Conference ICETA 2009 performed in November 2009 in Stara Lesna
- Conference MVP implemented in September 2010 in Banska Bystrica
- Conference 2010 ICETA implemented in October 2010 in Stara Lesna
- Roadshow Modern teacher implemented in November 2010 in Zilina, Presov, Kosice, Zvolen, Nitra and Bratislava

ACKNOWLEDGMENT

We would like to thank all members of project teams who have contributed to the presented work, the result of the Slovak national projects Modernization of education at primary and secondary schools (ITMS project codes: 26110130083, 26140130013, 26110130084, 26140130014) supported by the European Social Fund.

REFERENCES

[1] Lehman M. M.: "Lifecycles and the Laws of Software Evolution", in Proceedings of the IEEE, Special Issue on Software Engineering, 19:1060-1076, 1980.

[2] Jarzabek S., "Effective Software Maintenance and Evolution: A Reuse-Based Approach", in Auerbach Publicatio, Taylor & Francis Group, ISBN: 0-8493-3592-2, 2007.

[3] Grubb P.A., Takang A.A., "Software Maintenance: Concepts and practice", SE, ISBN 978-981-238-425-6, World Scientific 2003.

[4] IEEE Std. 610.12, "Standard Glossary of Software Engineering Terminology", IEEE Computer Society Press, Los Alamitos, CA, 1990.

[5] Pigoski T. M., "Practical Software Maintenance – Best Practices for Managing Your Software Investment", John Wiley & Sons, New York, NY, 1997.

[6] Erlikh, L., "Leveraging Legacy System Dollars for E-Business", in IEEE IT Pro, May–June 2000, pp. 17–23.

[7] Port, O., "The Software Trap — Automate or Else", in Business Week, 3051(9), 1998, pp.142–154.

[8] Allen C., "Software maintenance – an overview", in British Computer Society, Programming & Software Articles, en-GB 3rd, February 2006.

[9] Canfora G., Cimitile A., "Software Maintenance", in Handbook of Software Engineering and Knowledge Engineering, volume 1,World Scientific, ISBN: 981-02-4973-X, December 2001.

[10] Fyson, M. J., Boldyreff, C., "Using Application Understanding to Support Impact Analysis", in Journal of Software Maintenance – Research and Practice, 10(2):93-110, 1998

Using of Multimedia and New Communication Technologies in Complete Computer Support of Education

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***Abstract*—The article describes practical application of multimedia and communication systems used at the process of education in Technical University of Košice.**

I. INTRODUCTION

In the framework of projects for development of infrastructure and modernization of IKT at Technical University of Košice, general contractor elfa, s.r.o. has arised a task for his subcontractor ViaNet, s.r.o. focused on particular progress and application of new information and communication technologies for everyday using in the process of education at the Technical University in Košice. The article describes the application of modern audiovisual technologies and video communication systems in the large capacity classrooms of the university.

Using of the modern audiovisual and communication systems in process of education at university increase undoubtedly the quality of education on the higher level. Audiovisual aids and communication technologies enables teachers using material of higher quality. Therefore students obtain more extensive information in better quality and also an opportunity to be in touch with modern technologies in their practical application.

The contact of students with modern multimedia and communication technologies in everyday life of education will help them to stop focusing on the technology as the barrier but move them to accept the technologies as the tool of modern way of education and also start to concentrate more to the information that are presented at the lecture.

II. DESIGN PROCESS OF THE "INTEGRATED MULTIMEDIA LECTURE DESK"

Integrated Multimedia Lecture Desk means complex solution containing of audiovisual and communication systems controlled by graphical interface of intuitive system of control. Integrated Multimedia Lecture Desk also contains different interface for connection of external systems of sound and projectors with projection screens .

A. External projectors with projection screens, cameras and sound systems

According to equipping of the large capacity classrooms with modern audiovisual systems, was necessary to involve the projectors with projection screens, camera technologies to the classroom environment and design high quality of the sound by integrated speaker boxes.

Figure 1. High capacity classroom with external projection systems and screens, cameras and speakers

There was necessary assume with using visualization systems in classrooms which contains two performance projectors and two electrically operated projection screens. Dimension of projection screens and projectors performance was designed according the dimensions and architecture of classroom environment.

There was replaced old classical blackboards by new ceramic boards with respect to the new audiovisual technology. Using of old classical blackboards and their dust has negative effect and decreases life and quality of using new technology.

We use four speaker boxes for the sound system in each classroom which are usually installed mainly on the front and middle part of the side wall with accent to the adequate quality of sound level in any place of classroom.

For the distance education and video communication reasons there was installed two cameras in each high capacity classroom:

i) High Definition camera for video communication system in the quality of 1280x720 pixels and 30 frames per seconds motion.
ii) High quality CCD camera that combines a high-speed, quiet pan/tilt with a wide-angle view and 40x zoom (10x optical + 4x digital), all in a compact, easy-to-use package.

The last challenge but not simple task was realization of cable distribution to each of these active system integrated in the environment of high capacity classrooms.

B. Audiovisual and communication systems

There was installed the Integrated Multimedia Lecture Desk in to the each high capacity classroom. In the process of Integrated Multimedia Lecture Desk design we

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was focused for next important points of requests with respect to daily of education process:

i) Installation of complete audiovisual and didactic technology of high capacity classroom into the one central place with possibility of secure lock and with respect for the operation environment request of each technology and subsystem.

ii) Integration of all necessary systems and technology important for daily using in process of education

iii) Integration of interactive systems which allows to work with different electronic document formats, 3D objects and software applications

iv) Design of simple way of control whole Integrated Multimedia Lecture Desk and systems inside with main focus on simplicity and final result of simple technology for daily use.

Figure 2. Audiovisual an communication systems of Integrated Multimedia Lecture Desk

We have designed Integrated Multimedia Lecture Desk after summarize all aspects and goals mentioned hereinbefore.

Basic interactive technology used in the Integrated Multimedia Lecture Desk are computer with keyboard and mouse, 17" inch touch display and 4,3" inch graphical touch display for desk control. On the right side of the desk are VGA, audio and 230V interfaces for laptops connection. On the top of the dest is installed interface for external USB memory or SD memory card connection.

The whole desk with particular systems are controlled through simple graphical interface with 4.3" inch touch screen programmed for easy of use and controlling of all systems during the education process. This is the main system which helps teachers to simplify they work with dest and provides them quickly startup or open up the any function of any technology that are needed. Thera are available wide range of audio inputs (total 6), then switching matrix of video inputs different sources (total 5) to output of any display and screen (total 4), to controlling the video communication system, sound systems and microphones.

The desktop screen of the computer and the particular running applications can be controlled not only by connected keyboard and mouse but also 17" inch touch screen situated on the top of the desk. The computer is one of the basic interactive application for the teachers during the they work. It enables for example to edit or draw into the presentations used during teaching.

On the left side of the desk, there is socket with documentation camera, which enable to view printed documents or 3D subject. Its high quality optics enables to zoom the details of small even very small subjects.

The last but not the easiest challenge was to develop the system of power control which power all the particular technologies in safe condition and reliable operation of individual integrated technologies will be ensured. The solution came as "one button solution". It turns off the whole desk with using the touch screen, the key or simply closing the top cover counter of the desk.

The main parts of the designed sound system are: amplifier, echo canceler, equalizer, mixer and microphones.

The main parts of visual systems, displays and screens are: video matrix which ensure the switching many of video sources to the elective range of accessible displays and screens.

The video sources usually are: video communication system, integrated computer, external laptops, DVD/VHS player, document camera.

Figure 3. Interactive and control systems of Integrated Multimedia Lecture Desk

Installation of all Integrated Multimedia Lecture Desks to the high capacity classrooms contains three main phases of process:

i) Installation of external visual systems such as projectors and projection screens, cameras and speaker boxes

ii) Integration of complete cabling and its ending in the place of installation of the desk

iii) Install all technology to the desk and preparation of the desk for final installation to the classroom environment and all systems setting and programming of control

iv) Desk transportation and installation at the destination

v) Set up systems to the real operation and final administrator training.

C. Video communication systems

The part of Integrated Multimedia Lecture Desk is also the video communication system produced by LifeSize, which ensure video communication in standard SIP and H.323. Despite this, the system enables to use Skype and "EVO" The World Wide Collaboration Network for the communication.

Thanks implementation of video communication system in environment of high capacity classrooms there is space for connecting with external participant. This is the way for realization of distance education for foreign students or to connect students with professors from foreign countries or peple from the real industry.

III. Further applications of Integrated Multimedia Lecture Desk

The Integrated Multimedia Lecture Desk can be adapt for implementation to smaller classrooms at elementary or secondary schools. Adapt them for particular applications and equipment to offer the teachers complete but easily controlled tool for educational process. On the other hand, playful and interactive tool for pupils and students. They can familiarize the technology that they can meet on higher level of their education or in life.

The desk can be integrated with interactive desks or added with didactical technique.

Introduction of video communication technology on lower levels of education can lead to motivation and inspiration in further education on higher levels and mediate the contact of students and professors or other interesting people from practice.

IV. Conclusion

The project of development of infrastructure and modernization of IKT on Technical University in Košice shows the importance of projects like this. Thanks the realization of the project, there is multitask and "alive" equipment of audiovisual technology in high capacity classrooms, which can be improved, developed and added new applications.

One of these applications is for example digitalization of education for passive participants that cannot attend the lecture. It can be understand as implementation of different streaming technologies for streaming of people and content video. The easy way of using ("One Button Solution") this kind of technology is main importance to keep them life in real operation.

System of digitalization, which ensure easy start of recording and online streaming lectures and after the end automatic save and publishing on the school web server for next education process. The result is that students would have access to presentations and content where they had absence. The presentations could be also provided to external foreign users as material of e-learning education process.

Integrated Multimedia Lecture Desk is already today prepared for the integration with system like this, where it ensure capture and provide audio and video outputs for further processing to other higher systems in process like systems for streaming and publishing.

Acknowledgment

The aim of the article is to refer to particular practical use of multimedia and communication technology in process of education on elementary, secondary schools and universities. We wanted to refer also to openness of the system of Integrated Multimedia Lecture Desk and its further possible application on lower levels of education and also the opportunity of integration with the other systems used for digitalization of education (e-learning).

References

[1] Zuzana Horváthova, *Using of information and communication technologies in education process*, Katedra UNESCO IRIE PF UKF, Tr. A. Hlinku 1, 949 74 Nitra, Slovakia, September 2005.

[2] LifeSize Communications, a division of Logitech, *Bring the World to the Lecture Hall in HD*, 2011.

[3] AMX, *AMX SchoolView Solutions*, 2011.

Influence of communication means in project oriented education

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***Abstract*—This article describes the results of previous research in electronic communication area. It deals with the organization and implementation of research, which goal was to find out the electronic communication impact at project oriented education effectiveness within the computer science courses at the Faculty of Education at Trnava University in Trnava.**

I. INTRODUCTION

With the arrival of new technologies the possibilities of communication in education will also be possibly changed. Communication is essential for teamwork within projects and can significantly affect learning processes and learning outcomes as well. New technologies open up additional possibilities for the learning communities' creation. But that requires acquisition of new communication skills for the teachers and students.

Communication has significant place in education. Intensive research has been carried out in the field of communication in education mainly in connection with new technology opportunities. Ohlund, Yu, Jannssch-Pennell a Digangi [1] presented the results of research in which respondents were divided into four groups according to the use of communication medium: (1) email, (2) chat, (3) email and chat, and (4) other communication tool. Respondents who use synchronous and asynchronous forms of online discussions were largely able to fulfil the required course activities. Research has shown that the combined synchronous and asynchronous online discussing maximize personal engagement in learning. Yout and Shapiro [2] reported a case study in which student's ranked higher asynchronous communication than synchronous communication. Johnoson G. M., J. Johnoson A. [3] [4] have done research which compared two WebCT communication tools, synchronous chat and asynchronous discussion. The research found that about 40% of respondents indicate that they prefer synchronous chat and 60% of respondents preferred asynchronous discussion. Experienced users decided more often to use chat instead of asynchronous discussion forum. Research also showed that about 43% of respondents identified that they learned best when used synchronous chat and about 57% of respondents identified the asynchronous discussion. Although these studies confirm that digital communication has become one of the basic skills needed for career advancement, but it involves more than just achieving computer literacy. Success in school and at work depends on knowing how to choose the right medium for the message, and then design and create various forms of communication.

II. THE RESEARCH REALIZATION AND ORGANIZATION

Within the complex research supported by VEGA grant we researched also how students use individual electronic communication mediums in the education process realized in the form of project oriented education. The research has been realized in fall term 2009-2010 at the Faculty of Education at Trnava University in Trnava. Students were split into two groups face-to-face, and blended learning group. The model, recommended by Turek, was used for planning and realization of the project oriented education [5].

The research goal was set as follow: to find out how form and means of communication impact the project oriented education effectiveness within the computer science courses. Following hypotheses were tested:

H1: Students prefer electronic communication medium with no regard of the education form.

H2: There is statistically significant difference between project assessments of students working with following mediums: 1. group – chat; 2. group – e-mail; 3. group – discussion forum; 4. group – face-to-face discussion.

H3: Duration of the communication medium usage has influence on the project assessments.

The research sample consisted of 171 students in the third year of undergraduate study full time in the fields of Teaching. Students were classified into four working groups according to the preferred communication medium. The first group used as the preferred medium synchronous chat, the second group used the asynchronous e-mail, third group asynchronous discussion forum, and the last group preferably used synchronous communication – face-to-face.

III. INTERPRETATION OF RESEARCH RESULTS

In Hypothesis H1, we assumed that students prefer electronic communication medium with no regard of the education form (Table 1, Table 2).

We found that electronic communications significantly outweigh a face-to-face communication and even students who were enrolled for face-to-face form of education have a higher percentage of use of electronic communication means (61,73%) compared with a face-to-face communication (38,27%). Based on these results we proved the validity of the hypothesis H1. The electronic

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communication means, which are largely based on impersonal and yet interactive communications are becoming increasingly popular among students and provide them with new opportunities in education. Whether the independence of electronic communication, where teachers and learners are not necessarily in the same place and at the same time during communication or gain greater opportunities to obtain information necessary for the development tasks within the project.

TABLE I.
THE CORRELATION BETWEEN THE USAGES OF COMMUNICATION MEDIUM

	Face-to-face	Electronic means
Percentage ratio	29,5	70,5

TABLE II.
THE CORRELATION BETWEEN THE USAGES OF COMMUNICATION MEDIUM DEPENDING ON THE FORM OF EDUCATION

Education form	Group	Face-to-face	Electronic means
Distance learning	1.group	29,04	70,96
	2.group	26,69	73,31
	3.group	27,46	72,54
Face-to-face	4.group	38,27	61,73

Facts, that electronic communication is currently developing, are confirmed by further results (Table 3).

TABLE III.
PERCENTAGE SHARE OF COMMUNICATION MEANS BY GROUPS

Groups	Face-to-face	Chat	Phone	E-mail	Discuss forum
% ratio of all means	29,5	27,8	1,6	31,1	10

The e-mail, asynchronous communication mean, was most often used by students in projects (31,1% of all communication means). The second most common used communication mean was a face-to-face discussion represented with 29,5% portion followed by synchronous chat with 27,8%. One of possible explanation is that students have more time to write messages with asynchronous means because the sender does not wait for an immediate response. This increases the ability to process information and may have a positive impact on the quality of the information.

Hypothesis H2 stated that there is statistically significant difference between project assessments of students working in groups using different communication means as preferred selection: 1. group – chat; 2. group – e-mail; 3. group – discussion forum; 4. group – face-to-face discussion. Research was oriented onto the influence of preferred means of communication, type of communication medium and length of communication on the results. The goal was to find out whether the results of each group are comparable and which one of communication means leads to improved results for project results. The method of analysis of variance ANOVA F (3,64) = 5,263, p = 0,0026 confirmed that between the project results are a statistically significant difference, so hypothesis H2 is valid (Figure 1).

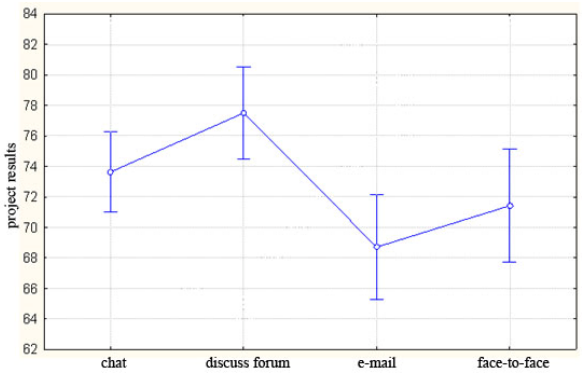

Figure 1. Influence of communication means on the results

Students achieved the best results with usage of discussion forum as preferred communication mean. Students preferably used e-mail achieved the worst results. Comparing results of different groups among themselves, statistically significant difference exists only between the second (e-mail) and the third group (discussion forum) (p = 0,0017) (Table 4).

TABLE IV.
TUKEY POST-HOC TEST - COMPARISON OF PEER GROUPS

Groups	Chat (p)	E-mail (p)	Discuss forum (p)	Face-to-face
Chat	–	0,115797	0,230079	0,766985
E-mail	0,115797	–	0,001782	0,709253
Discuss forum	0,230079	0,001782	–	0,065365
Face-to-face	0,766985	0,709253	0,065365	–

Results of described research showed, that inclusion of a discussion forum as a means of communication in the project oriented education can improve it taking into account the limits bordered the research.

Hypothesis H3 stated that the length of interpersonal communication using communication means among the members of project team has an impact on the results of the project. Multiple linear regression (R2 = 0,15; F(4,64) = 2,734; p = 0,036) showed that only the length of a face-to-face communication had statistically significant (p = 0,017) effect on the results of the project (Table 5).

It is possible to conclude that the longer lasted face-to-face communication in solving students' project, the better were results of the projects (Figure 2). However, the validity of hypothesis H3 is not confirmed because other variables (time spent on the discussion forum and chat), no significant affected the evaluation of the project.

TABLE V.
RESULTS OF MULTIPLE LINEAR REGRESSIONS WITH THE RESULTS OF THE EVALUATION PROJECT AS A DEPENDENT VARIABLE

	Beta	SE Beta	B	SE B	t(63)	p
Group	-0,294	0,133	-1,859	0,837	-2,221	0,030
Face-to-face in minutes	0,316	0,129	0,011	0,005	2,457	0,017
Discuss in minutes	0,135	0,117	0,166	0,144	1,152	0,254
Chat in minutes	0,131	0,127	0,003	0,003	1,032	0,306

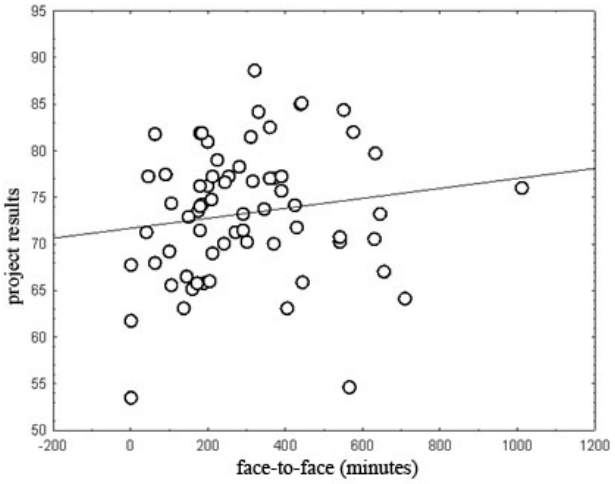

Figure 2. Multiple linear regression

IV. CONCLUSIONS

The research results showed that preferred communication medium and communication duration have an impact on the project results. It also showed that the discussion forum is a suitable communication medium for the project teamwork. Based on these findings, it is suitable to include this communication medium in the project oriented education.

Electronic communication expands everyday in the whole society, mainly in industry and business. Education cannot ignore this trend and moreover, needs to prepare students for life. The success of graduates in the job market is dependent on their knowledge and skills. Research described in this article has ambition to develop educational process by improved understanding of the electronic communication use in project oriented education.

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REFERENCES

[1] Ohlund, B., Yu, C. H., Jannssch-Pennell, A., & Digangi, S. A. (2000), *Impact of asynchronous and synchronous internetbased communication on collaboration and performance among K-12 teachers.* Journal of Educational Computing Research, 23, 405-420.

[2] Shapira, P., & Youtie, J. (2001), *Teaching with Internet and multimedia technologies: Insights from an online seminar on industrial modernization.* Journal of Planning Education and Research, 21, 71-83.

[3] Johnson, G. M., *College student psycho-educational functioning and satisfaction with online study groups.* Educational Psychology, inpress.

[4] Johnson, G. M., *Synchronous and asynchronous text-based CMC in educational contexts*: A review of recent research. TechTrends, in press.

[5] Turek, I.: *Didaktika 2008*. Iura Edition, spol. s. r. o., Bratislava 2008. ISBN 978-80-8078-198-9.

[6] Rimarčík, M.: Viacnásobná regresia. Dostupné na: http://rimarcik.com/navigator/mr.html.

[7] Rimarčík, M.: Analýza rozptylu (ANOVA). Dostupné na: http://rimarcik.com/navigator/anova.html.

[8] Katina, S.: ANOVA modely. Dostupné na: http://www.defm.fmph.uniba.sk/~katina/StKaANOVAdoplnkyPCIIstudenti.pdf.

Learning Chemistry Through Puzzle Based Game: Atoms to Molecule

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***Abstract*— This paper highlights the design of a chemistry based puzzle game. The design of the game is meant to teach basic concepts of chemistry related to covalent bonds. The area of Educational Technology is still not so developed for young learners. An interactive technology is required for learning effectively and efficiently. The result is Atoms to Molecule (A2M). In A2M the environment of the levels are designed as such a player will have complete feel of chemistry lab. This game tries to intact fun with education. In this paper we are trying to highlight the features of chemistry objects which are used in our game. While teaching the basic concept of Chemistry, like bonds between atoms and how molecules are formed teacher usually gives examples to define the formation of bonds. However, the concepts of atoms and molecules are difficult for students to imagine. This game A2M has clearly presented the concepts lying behind the formation of bonds, game rules and simple game levels is chosen as the teaching aid along with a fun puzzle game.**

***Index Terms*— Chemistry, Game Based Learning, Game Design, Puzzle.**

I. Introduction

GAME designing is becoming very popular now a day. This is because now a day's games are not made only for fun and entertainment but also for education [1]. Digital games (video games or computer games) are positively accepted among children and teenagers [2, 3]. Multimedia based learning environment are more efficient than reading contexts. It can easily grasp interest of students. However it is generally found Digital Games Based Learning (DGBL) cannot maintain the fun element up to that level. It is becoming very challenging to combine education with fun in equal ratios. Computer games with exciting interactive activities and interesting multimedia provide a way to motivate students to learn actively and interestingly. Normally the time period of classes are 45 – 50 minutes, so it is very important to design simple, short and interesting games. Education games, which take 20 hours to teach, can become boredom again. Some educational games are very complex. Educational technology still lacks in research on how to design game environment that foster knowledge construction and deepen understanding and problem solving while engaging and entertaining the player at the same time [4].

Teachers usually need to explain the concepts of formulation of molecule from atom, which can be very difficult to demonstrate. It motivates this paper of applying the game-based learning approach to assist students in manipulating and observing the relationship of atoms to form molecules [5]. Research data also showed that the use of games in education is perceived as a useful tool for learning and helped to engage students in educational experiences towards achieving specific learning goals and outcomes [3, 6, 7, 12].

The game A2M is interesting and more acceptable for students to realize the abstract concepts through the fun and interactive world of the game. With our survey, some practitioners used the puzzle games as a teaching tool [8, 9, 10]. It seems that the game is interesting and more acceptable for students to realize the abstract concepts through the real world examples.

This paper is organized as follows. First we discuss the Game Description. Second, we discuss the details of the different objects used in the game. Third, we introduce the design of different levels used in the game and scoring patterns. Last, we report the qualitative and quantitative findings from a user study with three groups of students.

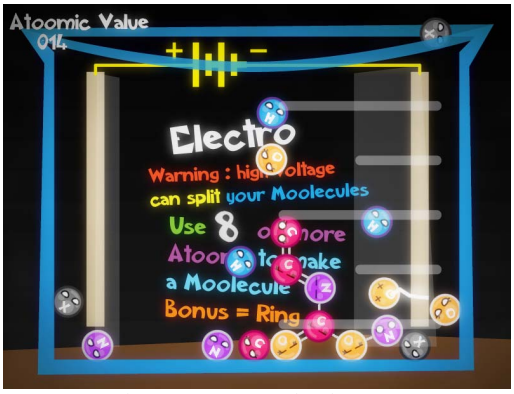

Fig. 1. Atoms to Molecule game.

II. Game Description

Atoms to Molecule (A2M) is a single player puzzle game where player is in a Chemistry lab. Each level consists of lab equipments and atoms. The levels start with the atoms entering from the top of the screen. The number of atoms in a level is constant and the type of atoms is generated randomly. Player can drag and drop the atoms to make bonds with nearest atom [11]. A player can easily replace the atoms by joining them to form molecules, this molecule disappears and new randomly generated atoms replace the used atoms.

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A player can make molecule by joining different atoms. The task of a player is to make molecules and solve different puzzles of Chemistry lab. Player can arrange atoms to make ring, linear, small or big molecules. The lab equipments in which A2M is played can be test tube, beaker, conical flask and other (see Fig. 1). The basic goal in each level is to make different kinds of molecules with different objectives. To make a complete molecule all the atoms in the molecule must be sleeping which can be achieved by using all their bonds (see Table 2).

A2M is a puzzle based game base on the covalent nature of atoms. Here the atoms are used as a puzzle piece and to form a molecule is to solve a puzzle. While solving these puzzle students learns to make molecule from atoms using covalent bonds, which can be single, double and triple.

III. Basic Game Objects

A. Atoms

The main character of the game is atom. The look of the atom is developed to be more attractive to the young learners. The symbol in the head and the circular body color suggest the type of element (see Table 1).

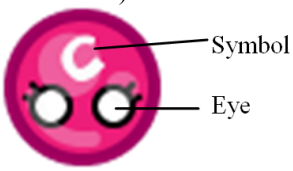

Figure 2. Details of Carbon Atom

The four elements with different number of bonds used in this game are Hydrogen, Oxygen, Nitrogen and Carbon. ElementX is an element, which can make variable bonds with maximum of three, designed to add fun in the game.

TABLE I
Atom Detail Chart

Element	Symbol	Color	Total Number of bonds
Hydrogen	H	Blue	One
Oxygen	O	Orange	Two
Nitrogen	N	Violet	Three
Carbon	C	Red	Four
ElementX	X	Black	Variable with maximum of Three

We have assigned the gender depending upon the total number of bonds an atom can make. The intension behind assigning the gender is to distinguish between odd and even number of bonds (see Table 2). For odd number of bonds in atom we have assigned boy e.g. Hydrogen. For even number of bonds in atom we have assigned girl e.g. Oxygen.

This assignment of gender leaves deep impact on children mind to easily figure out between odd and even number of bonds an atom can make. Thus this assignment serves both the purpose of education and entertainment.

The different eye states are connected with different state an atom can have (see Table 2).

TABLE II
Atom Eye State Chart

State	Look (Girl)	Look (Boy)	This happens when
Normal			The atom in the free state.
Open			The atom is bonded with some other atom but all its bonds are not satisfied. In this state the atom jitters.
Cross			It comes in contact with some enemy causing it to break all its bond. It changes back to normal. This is a short time effect.
Happy			All the bonds of the atom are satisfied. This is a momentary effect; it automatically changes to sleep after some times.
Sleep			All the bonds of the atoms are satisfied.

Boy atoms are Hydrogen, Nitrogen and ElementX.
Girl atoms are Oxygen and Carbon

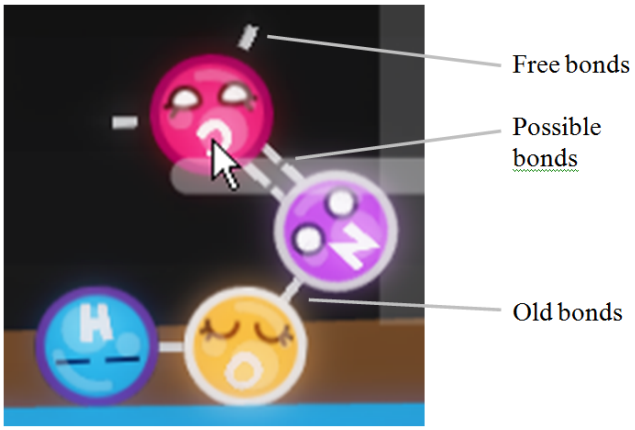

Figure 3. Different kind of bonds.

B. Bond

When an atom dragged and dropped near an atom a bond forms between them. Bonds can be Single, Double or Triple. The atom always tries to make the highest number of bonds. When an atom is dragged it shows the bonds left to be formed and when it is brought near another atom it show the possible number of bonds that can be formed (see Fig. 3).

C. Bond Angle

Bond angle define the angle in which the newly attached atom will arrange itself. The angles in which an atom can be attached are 0, 120, 240, 60, 180 and 300 degree. The angles are chosen so that no two atoms are very close to each other.

D. Game Enemy

1) Radioactive Atom

This used as an enemy in the game. It has a radioactive sign on its head and the expression of the eyes shows anger. In the game it emits green smoke (see Fig. 4). It moves randomly in the level area and breaks all the bonds of the atom that comes in contact. To make it inactive we can drag and drop it an empty space of the level area, but the moment it come in

contact with other object it becomes active again. As radioactive substances are very harmful for our environment, similarly we tried to demonstrate that radioactive substances are enemy to our molecular structure in the game.

Figure 4. Radioactive Atom in action

2) Electrode

They are static enemies, they can't move around like the radioactive atom. When the atoms come in contact with the electrode it gets a heavy shock and its bonds get split (see Fig. 1).

IV. GAME MODES

A. Adventure

Adventure Mode is the primary mode, and it allows a player to learn the ways to make molecules and then advancing to the expert levels. Adventure Mode is divided into 8 stages. The stages and how it is related to learning objective are as shown on Table 3.

B. Lab Setup

Lab Setup is a sand box mode where a player can setup a lab (see Fig. 7). Lab Setup is divided into:

1) Equipment mode:

In this mode player can add, move, rotate and clamp lab equipments in the lab area. The equipments are under physics simulation in this mode, but the atoms are not simulated and are kept transparent, i.e. no collision takes place with the atoms.

Lab Equipments that are provided are electrodes, thermometer, pH scale, funnel, test tube, conical flask, measuring cylinder, beaker and clipboard.

2) Atomic Mode:

In this mode a player can add or remove atoms in the Lab area. Molecules can be formed using the added atoms. The types of atoms added are generated randomly. But the molecules formed will not be removed automatically in this mode as it happens in case of Adventure mode. In this mode atoms are under physics simulation but equipments are static.

V. SCORING

The scoring pattern is chosen to suit the chemistry environment. When a molecule is formed and it meets the level objective "Atomic Value" (AV) is awarded in the form of scores (see Fig. 5). Sometimes AV is associated with a bonus multiplier, which gets multiplied with the AV and the total is awarded. The total AV obtained in the level is summation of all the AV of the molecules; it is displayed in the top left corner of the game screen in the levels of the Adventure mode (see Fig. 1).

TABLE III
ATOM DETAIL CHART

Level	Description	Learning Objective
Tutorial	This is an introductory level here the different atoms used (see Table 1) in the game are introduced. The molecule a player has to make is shown as a hint in the background of the level.	The player learns the game controls and tries to make some basic molecules.
Ring-O-Ring	In this level a player have to make 8 ring molecules to move to the next level.	The player learns to make ring molecules.
Absolute Zero	This is a fast-paced level the bonus in the level is ring bonus. In the level a Kelvin scale thermometer showing the temperature is constantly increasing. A player must make molecule to drop the temperature to Zero Kelvin. The molecule with rings gets a bonus and the temperature decreases quickly.	The player learns to make bigger ringed molecules within specific time.
Clear All	In this level a player has to make a single molecule using all the 10 atoms present in the level for five times.	The player learns the trick of using all the bonds to form a single molecule.
Electro	The level contains an electrode which decreases the level area. The objective of the level is to make molecule having 6 or more atoms, which increases up to 16 at the rate of two atoms at a time. (see Fig. 1)	The player learns to make bigger molecules efficiently using less area in the screen.
pH Scale	This is a fast-paced level too; the bonus in the level is Hydrogen Bonus. A pH meter showing a constant increase, a player must make molecule containing more hydrogen to drop the level in the pH meter.	The player learns to make a molecule utilizing maximum number of hydrogen.
Clipboard	In this level is player must make the simple molecular formula given in the bottom of the screen.	The player learns to make molecule of a given molecular formula.
Radio Active	This level contains four radioactive atoms. The objective is to make molecule having 2 or more atoms, which keeps increasing two at a time up to 10.	The player learns to tackle game enemy while making molecules.

A. Atomic Value

Atomic Value (AV) of a molecule is the sum total of all atom's AV present in it. AV of an atom is the number of atoms it is bonded to. So more atoms it is attach to, more is the AV and more is the score. For Example: A carbon attached to an oxygen and two hydrogen atoms, Molecular formula CH_2O, AV of the molecule = 3 (for carbon) + 1 (oxygen) + 1 (hydrogen) + 1 (another hydrogen) = 6.

B. Ring Bonus

In most of the levels if a player can form ring molecule the AV gets multiplied with a factor. The factor depends upon the number of rings in the molecule. For Example: If a molecule have 2 rings AV will be multiplied with (2 + 1) = 3 times.

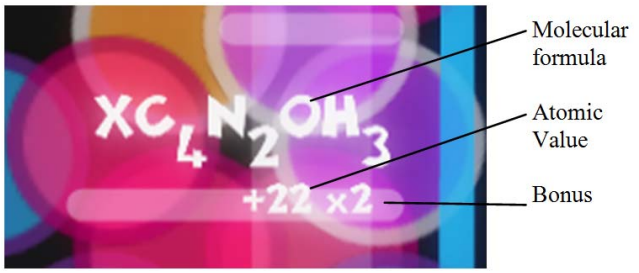

Figure 5. A molecule disappearing showing up Molecular formula, Atomic Value and a bonus multipler.

C. Hydrogen Bonus

With Hydrogen bonus the AV is multiplied with the total number of Hydrogen present in it. So a player needs to attach more hydrogen to a molecule to get more bonuses.

VI. Technology

We uses Microsoft XNA [13] cross-platform game engine, using C# and object-oriented technology to develop A2M. For the Physics simulation we used Box2D.XNA [14] a C# port for Box2D.

The collision detection of Box2D.XNA becomes very poor when any molecule, a complex structure of bodies connected by joints, comes in contact with other dynamic body, equipments. The poor collision was forcing the atoms to tunnel through the moveable equipments, dynamic body, but it was not affecting the non-moveable table top, static body [14]. So in Lab Setup two different mode like Atomic and Equipment modes were created to solve the collision problem. In the Equipment mode equipments are dynamic which allows it to move and the atoms are kept transparent to avoid collision between atoms and equipments, where as in the Atomic mode equipments are kept static and the atoms and molecule collide with the equipments.

VII. User Study

A. Goals

A user study with 15 student of different age group was made, to understand the play experience and improve the game design [15]. The research questions were designed to gather the feedback to improve A2M and see how the design was helpful in learning the basic concepts of chemistry. It also determined how the characterization of the chemistry elements helped to grab the attention of the young learners. Our main goal is to realize how learning games can grasp the interest of the player and how much knowledge they gain after playing the game. We hoped to understand the patters of learning among children through games.

B. Participants

We selected fifteen participants varying from age group of 10-20. We categorize them according to their age Group 1 (10-13 years), who are still not introduced to very basic concepts of chemistry, Group 2 (14-16 years) who have started with learning chemistry, Group 3 (17-20 years) who want to explore new things out of this subject. Few of them have never played any educational game before. Four of them were girl. Three of them were very poor in bonding concepts of Chemistry. Five were very curious about game play.

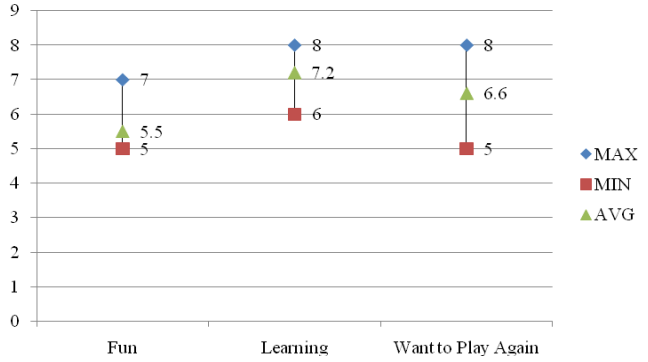

Figure 6. Feedback Scores.

C. Procedure and Setting

The user study included three parts, first the player learned the game interface, and we demonstrate a small demo instructional video of the game [16]. A researcher gave an introduction to the game controls by following demo instructional video of the game play. Second the participants were instructed to stand in queue in the increasing age group. 4 students belong to each category. Students were introduced to the first level of the game i.e. tutorial level and were allowed to play other levels of the game. Third, the participants were asked few question related to learning through games and game play. The user study was conducted in an exhibition where we presented our game to school students.

D. Measures

1) Observation

A researcher took observation notes during game play, to record interesting movements of play and to generate related questions for the interview. The observation included how the player interacts and the reaction of the player on their first interaction with the game play.

2) Questionnaire

The questionnaire was divided into three sections: feedback about the game play, Chemistry concepts learned after playing A2M and about interesting aspects of the game. We used cross-checking questions to address the problem of misreporting.

3) Interview

At the end of the user study, we conducted a semi-structured interview. The interview focused on understanding the subjective experience of the players, including the strategies they adopted, things they learned, what made them adhere to the game, and the comparison between this game and other educational games they had played before.

E. Findings and Discussion

1) Feedback About The Game

We interviewed the students about what they like and dislike. We got positive feedback about the graphics which

included characterization of atom, bonding system and the different lab equipments which build up the whole atmosphere of the game. They were comfortable with the controls of the game play which simply uses mouse to drag and drop. They found it very simple and effective way of learning covalent bonding. The negative feedback which we got about the game was that the types of atoms used were limited, only concepts of covalent bonds were shown.

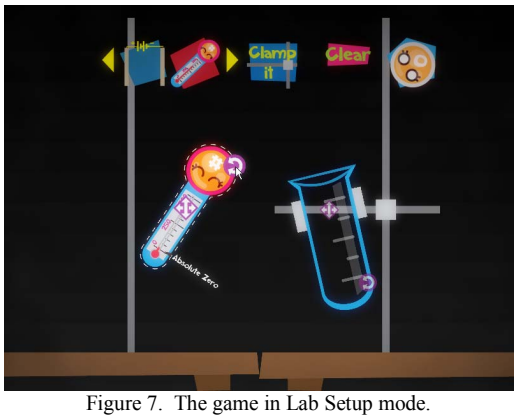

Figure 7. The game in Lab Setup mode.

2) Chemistry Concepts Learned

The feedback about the Chemistry concepts they learned while playing the game varied according to the age group. Students belonging to first group find it more entertaining rather than educational (2.3/5). The second group students find it quite educational (3.5/5), they find A2M an interesting way to learn covalent bonding (4.1/5). The third group students find the lab setup (see Fig. 7) very useful (3.8/5). They like the synchronization of chemistry concepts with different levels of the game (4.6/5).

3) Interesting Aspects

This user study had some initial findings on the interesting aspects of the game. In the questionnaire, the students found the game enemies to be well designed (4.4/5); they liked the breaking of bonds with the help of electric shock in Electrodes (3.8/5). They find the lab setup to be really interactive and well designed (4/5). They liked the eye state of atoms to define their states (4.8/5). They preferred more levels in the game (2.4/5). They felt the difficulty of the level moderate (3.2/5).

We also observed that when the students Drag and Drop to join the atoms of Hydrogen for the first time to make a molecule of Hydrogen, they get the feel how molecules are formed and they started to create all kinds of molecules which they have came across in their text book. After making the first molecule of Hydrogen most of the student wanted to create Water (H_20) molecule as it is a very basic molecule. As they familiar with the game play they were exited to move to the next level before completing one.

The user study of A2M showed that it can be used as educational tool which helped us in learning through games.

VIII. Conclusion And Future Work

We have discussed the basic design of A2M and how it is related with the basic concepts of covalent bonding. We have already discussed about the design of atom, and other details like what elements are used, how many bonds an element can form, and their eye expressions (see Fig. 3). We have tried to explain type of bonds it can form. Details of different levels are discussed. Though A2M is educational game but to add fun we have used enemies which are related to other concepts of chemistry.

The score is given in the form of Atomic Value and other bonus is added in the game. Our main contribution is to demonstrate a practical approach of covalent bonding. In the meantime, we hope to explore more interesting concepts of Chemistry which can be added to our game.

References

[1] Edu-Games, http://en.wikipedia.org/wiki/Edu-Games.
[2] Rubijesmin Abdul Latif. Understanding Malaysian students as gamers: experience. Proceedings of the 2nd International conference on Digital interactive media in entertainment and arts, 2007, pp. 137-141.
[3] Mireilla, B. Assessing the educational potential of video games, October, 2005, pp. 1-18.
[4] Kiili, K. Evaluations of an experiential gaming model. An Interdisciplinary Journal on Humans in ICT Environments, Vol. 2(2), October, 2006, pp. 187-201.
[5] Li Caii, Fangyu Liul, Zhihong Liangi. The Research and Application of Education Game Design Model in Teaching Chinese as a Foreign Language.
[6] Vasiliou, A. & Economides, A.A. Game-based learning using MANETs. Proceedings of the 4th WSEAS/IASME International Conference on Engineering Education, Agios Nikolaos, Crete Island, Greece, July 24-26, 2007.
[7] Garcia-Barcena, J. & Garcia-Crespo, A. Game based learning: a research on learning content management systems. Proceedings of the 5th WSEAS International Conference on Educational Technology, Tenerife, Canary Islands, Spain, December 16-18, 2006.
[8] Binary Color Device from Cut-the-Knot, http://www.cut-theknot.org/pythagoras/bicolor.shtml, Mar. 2010.
[9] Logic Puzzle from Puzzler Paradise, http://www.puzzlersparadise.com/page1034.html, Mar. 2010.
[10] Wolf Sheep & Cabbage from Plastelina Interactive Logic Games, http://www.plastelina.net/game1.html, Mar. 2010.
[11] 2D Boy, World of Goo, http://www.worldofgoo.com/, 13 October, 2008.
[12] Nor Azan Mat Zin 1, Wong Seng Yue. History Educational Games Design, 2009 International Conference on Electrical Engineering and Informatics 5-7 August 2009, Selangor, Malaysia.
[13] Microsoft, App Hub, http://create.msdn.com/, March 4, 2004.
[14] Erin Catto, Box2D Manual, http://www.box2d.org/manual.html, 2006.
[15] Barbara M. Wildemuth, Why Conduct User Studies? The Role of Empirical Evidence in Improving the Practice of Librarianship. Proceedings of INFORUM 2003: 9th Conference on Professional Information Resources, Prague, May 27-29, 2003.
[16] Duy-Nguyen Ta Huynh, Karthik Raveendrany, Yan Xuz, Kimberly Spreenx, Blair MacIntyre. Art of Defense: A Collaborative Handheld Augmented Reality Board Game.Proceedings of Sandbox 2009: ACM SIGGRAPH Video Game.

Information systems architecture modeling based on loosely coupled structures: an e-learning use case

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Abstract-Traditional approaches to information system architecture development have a little concerns with information technology interdependency. They are sustained in a positivist vision of the world, where the information systems, can be constructed from a set of requirements, done by a detached observer, who captures or elicits it. Organizations are each more concerned about information flow and knowledge availability as the central element for innovation and empowerment. This flow and knowledge have always a relation of interdependency. There is clear construction of a technosocial system whose relevance and differentiation come from user interrelation with information technology. It's the structure of this technosocial system that is the key element for the information system architecture dynamic development. This paper presents information technology as a commodity, resulting from a positivist development, and blueprints a definition of three loosely IT coupled structures namely, software as service, computation as a service and infrastructure as a service, structured under an information system modeling architecture. This modeling approach addresses an interpretive vision, and aims to give directions to achieve and promote differentiation, for enterprise development. An exploratory use case, regarding a two-year e-learning project, is presented as a result of the adoption of the presented modulation vision.

Keywords: information system architecture, information technology, commodity, interpretivist, positivist, technosocial systems,

I. INTRODUCTION

Today organization success, this is only possible and clearly depends, on its ability to sustainability explore information technology (IT) to support its interaction needs with the ecosystem, where ecosystem is the set of elements that organization uses and develops. This is clear sustainable in the fact, that is not possible, to manage the huge amount of available information, that flows into the enterprise ecosystem, without having the correct technological architecture and infrastructure. In this management task, a modeling approach into the design of an information system architecture can be a formal differentiating factor [1].

But dealing with this enterprise ecosystem, with its dynamic changes, puts a challenge into developing a clear approach to enterprise information system architecture modeling. The most relevant consequences for this architecture definition, will be the clear ability to deal with change, reduce costs or improve information system resources [2].

Fig. 1 presents expected results of the development of enterprise information system architecture at the enterprise level [2].

Academic Studies	
Systematic Literature Review (50 studies)	(1) increased responsiveness and guidance to change; (2) improved decision-making; (3) improved communication & collaboration; (4) reduced (IT) costs; (5) business-IT alignment; (6) improved business processes; (7) improved IT systems; (8) re-use of resources; (9) improve integration; (10) reduce risk; (11) regulatory compliance; (12) provides stability
SIM EA Survey, 2007 [Salmans and Kappelman, 2010]	(1) improves interoperability between information systems; (2) improves utilisation of IT; (3) aligns business objectives with IT investments; (4) more effective use of IT resources; (5) better situational awareness; (6) more responsive to change; (7) improves organisational communications and information sharing; (8) assists with organisational governance; (9) improves ROI from IT spending; (10) less wasted time/money on projects which do not support business goals/objective; (11) more effective at meeting business goals; (12) improves IS security across the business; (13) better collaboration within organisation; (14) improves communications between the organisation and IT department; (15) reduces IT complexity; (16) reduces organisational stovepipes; (17) faster development and implementation of new IS; (18) standardises organisational performance measures; (19) improves communications within organisation
Professional Studies	
Infosys EA Survey, 2007 [Aziz and Obitz, 2007]	(1) reduced IT cost; (2) higher business and process flexibility; (3) improved customer satisfaction; (4) enabling of business and process change; (5) better business-IT alignment
Infosys EA Survey, 2009 [Obitz and Babu K, 2009]	(1) improved customer satisfaction; (2) reduced IT cost; (3) business process improvement/ standardisation; (4) better business-IT alignment; (5) higher business and process flexibility
TOGAF 9 [The Open Group, 2009]	more efficient IT operations; lower IT costs; maximum ROI from existing IT; reduced risk for future IT investments; reduced IT complexity; faster, simpler, and cheaper procurement
Zachman International [Zachman, 2001]	(1) alignment enabler; (2) integration enabler; (3) change enabler; (4) reduced time-to-market
The benefits from the literature review, Infosys, and SIM surveys are ranked based on how often they were mentioned by authors/respondents. The benefits from Zachman [2001] are listed in the order presented by the author, though it is not clear whether any ranking was implied.	

Figure 1. Based on [2].

In this Fig. 1, is clearly present a positivist vision, by one side regarding the academic studies, with goals that start with the word improve and fundamentally, IT related. By another side, professional studies, address the same concern and in the two most-used models, TOGAF [3, 4] and ZACHMAN [4-7] this is even clear, with words like faster, alignment, efficient and integration.

This positivist vision of IT development gives supports to the conclusion that processes [8] and information technology (IT) [9, 10] as computation and infrastructures, are becoming a commodity utility.

If we look into the word alignment, presented by ZACHMAN, it's quite controversial, since alignment, is a long-time information system research problem with a long history of fallbacks without being yet mastered [11-14].

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This paper is developed to present a blueprint of the model that integrates the IT as a commodity utility and present e-learning has a use case for this discussion. In section 2, are presented the fundamental concepts. The method used is developed in section 3. At section 4 results are presented and in section 5 a discussion of paper concepts and future direction are put in place.

II. FUNDAMENTAL CONCEPTS

A. Model blueprint

Enterprise faces today a set of challenges that are closely related with the unpredictably of change arriving in the form of interaction complexity. Complexity, and its related use with IT, has come to stay [11, 15, 16]. Interdependencies generate a huge amount of information that is only manageable with the correct information system architecture, creating a clear technosocial system. This technosocial is the resulting structure of a unique set of interactions, at different structure levels, that comes from interaction between user and IT and that evolves along space and time.

When we look into traditional information systems, modeling approaches like TOGAF [3, 7] or ZACHMAN [5, 7], they are unable to formalize the structure of the information system architecture as set of commodities' utilities, since they rely on a positivist vision of the problems, or even demonstrate any concern about interactions.

When we add the concept of commodity utility, as a set of structures, having assigned basic rules, put together to achieve a more complex behavior, we need to change the paradigm and adopt an interpretive vision, to understand what kind of relation are developed between that structures.

The exercise, put on the blueprint design of a modeling approach based on the information effects, is presented in Fig. 2.

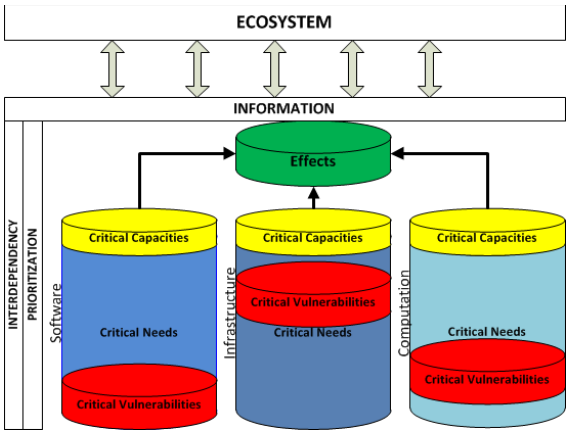

Figure 2. Updated from the information effect planning model [17]

This model blueprint presented on figure 2, explores the concept that organization survives in a technosocial ecosystem. This technosocial system is the resulting architecture of structures that result from interactions with IT in persecution of information effects, trough space and time. It's focused on the information effect, trough the development of the concepts of dynamic enterprise architecture with the integration of information technology structures as commodity utilities.

The three fundamental constructs are:

- Infrastructure, as infrastructure as a service (IaaS);
- Software, as software as a service (SaaS);
- Computation, as computation as a service (CaaS);

Each of this construct is a structure that is loosely coupled with the other, but from whose interdependence is supported the information effects.

Using this notion, it assumes that information technology, are commodities to support information effects and describes its critical capacities, needs and vulnerabilities. This IT can still be developed from a positivist vision and to "have" IT is not same to be able to manage the right information effect.

Presented model addresses core enterprise information system architecture modeling centered on the need of an architecture that adjusts its characteristics dynamically for enterprise sustainability and that is able to discover the right set of structure that can support the right information effect.

B. E-learning

E-learning has been seen by enterprises as a way to improve information flow for knowledge improvement and achievement. Been basically, a web-based system that makes information flow for knowledge, and that is available to users or learners disregarding time restrictions or geographic proximity. Having, as often presented advantages, availability and flexibility, when related with traditional face-to-face, too many projects have costly high failures. Addressing this problem much research has been made in the discovery of the factors for success.

In e-learning and according to [18] it is possible to define success factors from which can be made different types of arrangements as in [19], whose reproduction is made on Fig. 3.

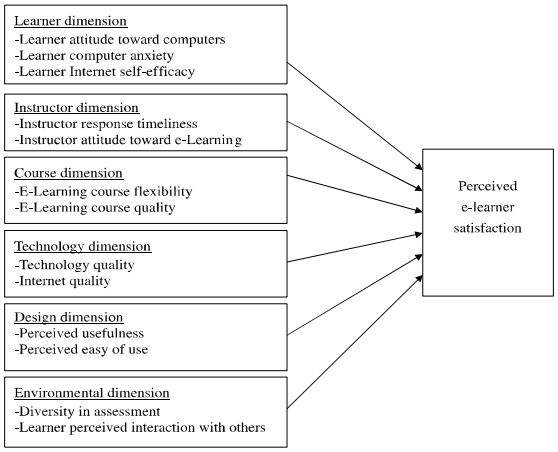

Figure 3. Perceived satisfaction constructs [19]

To be able to develop a consistence management of information flow to knowledge its can be considered that the information system architecture must be able to answer to this.

III. METHOD

The proposed model blueprint presents the use of a commodity utility for each component in the modeling of the architecture of the information system that will support, in this use case, the development of the e-learning project.

The approach used was an action research [20]. A review of the literature and a study of some practical cases were done, and the result was:

- Using Moodle as content management for e-learning [21], has the SaaS. Moodle solution was put in place and developed regarding the commodities concepts and relevance in e-learning community [21, 22].
- The IaaS and CaaS were achieved from in place available technology and already used for other tasks. These elements were available at the organization data center. For the IaaS, was available a Gigabit Ethernet LAN and a WAN access with 100Mb velocity. In CaaS sides were in placed Linux OS and Intel processing serviced it.

A. Case study

The case study is a two years project supported on one teaching courses related with animal research done under a scientific research institution. Courses evaluated are characterized in the table 1.

TABLE I. CASE STUDY COURSES CARACTERISTICS

Description	Year	Nº Students
Laboratory Animal Science Course, CN10	2010	27
Laboratory Animal Science course FELASA Cat C	2011	25

The main goals of the course can be described as the ability to obtain an appropriate training in animal biology, experimental techniques and other relevant topics as a prerequisite for responsible conduct with animals in research. In Europe, the standard for such training is set by FELASA (Federation for European Laboratory Animal Science Associations). To be considered competent to work with animals, a scientist should have a degree in a life-science discipline and have participated in a basic course in Laboratory Animal Science.

The courses analyzed on this case study follow the recommendation of FELASA for laboratory science training for scientists (Category C). The course combines theory (lectures, self-study) with practical exercises and group assignments. Focus is on how to design, plan and carry out experiments to minimize animal harm.

These are an 80-h course either over two subsequent weeks or as modules of 3-5 days over one month. This course gives the necessary training to obtain a permit to work with animals in most European countries. To get the actual permit, it's necessary to apply to the competent authority. In Portugal, *Direcção Geral de Veterinária* handles this permits.

Attending this course is a first step to meet the challenge of doing good research with animals in a responsible way. But laboratory animal science is a developing discipline, and what is best-practice today may not be so in five years.

The course contents address the following themes:

- Biology and husbandry of laboratory animals
- Microbiology and disease
- Health hazards and safe practices in the animal house Design and conduct of animal experiments
- Anesthesia, analgesia and experimental procedures
- Alternatives to animal use, Ethical aspects and legislation
- Analysis of scientific literature
- Project work for Cat C course

B. Results

To conduct results analyzes, regarding the expected resulted environment, had the same set of questions on the first and second years.

Table 2 shows the questions for each year.

TABLE II. COURSE EVALUATION QUESTIONS

	Question
1	How useful was the site as a central resource of information?
2	How user- friendly was the site?
3	What is your view of e-learning?
4	E-learning is preferable to traditional lectures?
5	Traditional lectures are preferable to e-learning?
6	It is good to have a mixture of different learning approaches in a course like this?
7	E-learning should only be used as a complement in topics where there is also a taught lecture or practical?
8	For some topics it is OK to have e-learning as the only approach?
9	This course had the right mixture of different learning approaches?

The questions where:

- Regarding the use, and that's a clear technology problem (1 to 3).
- Perception of what is e-learning (4 to 6).
- Content available and complementarity between digital and presence (7 to 9).

The valorization was done according to a scale from 1 to 5 where 1, was not at all useful, and 5 was, very useful.

Figure 4 presents results regarding each year and responses.

	N= 27						N=25					
	2010						2011					
Question	1	2	3	4	5	NR	1	2	3	4	5	NR
1	0	1	0	**9**	**16**	1	0	0	0	**7**	**18**	0
2	1	1	4	**14**	**7**	1	0	1	3	**10**	**11**	0
3	0	1	3	**12**	**10**	1	0	0	3	**11**	**11**	0
4	0	7	**12**	**2**	**3**	1	0	5	**14**	**5**	**1**	0
5	0	2	**2**	**12**	**8**	2	1	3	**11**	**8**	**2**	0
6	1	2	**5**	**5**	**16**	1	0	0	**1**	**3**	**21**	0
7	2	1	**3**	**11**	**9**	1	2	1	**5**	**9**	**8**	0
8	2	5	**5**	**9**	**5**	1	0	4	**6**	**5**	**10**	0
9	0	0	**6**	**11**	**9**	1	0	1	**3**	**15**	**6**	0

Figure 4. Evaluation results

IV. Conclusion

Question's results presented in figure 4 shows that there is a clear relevance of the IT world. The use of commodities utilities allowed to achieve the perceived value of e-learning and the use of commodity's utilities, that is common to many other e-learning environments, allows the technology to achieve the information effect.

When a correlation of this answers results is made with the critical success factors is relevant to find that user perception, about what is e-learning, is a relevant factor, found in answer to question 4 to 6, centered in an upper valorization.

When looking into the perceived satisfaction constructs and to the blueprint of the model of information system architecture, there are considered relevant success factors that are architecture information flow related. Environmental, design, technology and course are presented in the blueprint model modeling regarding ecosystem, effects, software, infrastructure and computation.

Some key aspects resulted:

- This approach, of using the development of the information system model has the ability to support e-learning.
- It's able to support the organization dynamics, achieving relevant impact in the sustainability and development of an e-learning project.
- User knowledge of what is e-learning is fundamental four the user experience.
- The use of a commodity learning environment as Moodle, supported in the define information system model, constructs the correct set of interdependencies between the different structures.
- Some structures, that are addressed for e-learning success factors, are really information system elements.
- Information technology is a central element for e-learning success.
- The availability of the e-learning is put in place a relevant technosocial system.

Further research, will be in the direction to know what structures can be discovered in this interdependent relation in the technosocial system and how this can be used to dynamic adjust the information system model. It will be a construct from data, information flow, to model. The model will evolve this approach in the direction to adopt a complex adaptive system behavior.

References

[1] Kettinger, W. J., Marchand, D. A. and Davis, J. M. DESIGNING ENTERPRISE IT ARCHITECTURES TO OPTIMIZE FLEXIBILITY AND STANDARDIZATION IN GLOBAL BUSINESS. *MIS Quarterly Executive*, 9, 2 2010), 95-113.

[2] Tamm, T. S., Peter B.; Shanks, Graeme; and Reynolds, Peter How Does Enterprise Architecture Add Value to Organisations? *Communications of the Association for Information Systems*, 28, 10 2011).

[3] Gerber, A., Kotze, P. and Merwe,A, V. d. Towards the formalisation of the TOGAF Content Metamodel using ontologies. *ICEIS 2010 - 12th International Conference on Enterprise Information Systems*2010).

[4] Leist, S. and Zellner, G. Evaluation of current architecture frameworks. In *Proceedings of the Proceedings of the 2006 ACM symposium on Applied computing* (Dijon, France, 2006). ACM, [insert City of Publication],[insert 2006 of Publication].

[5] Espadas, J., Romero, D., Concha, D. and Molina, A. *Using the Zachman Framework to Achieve Enterprise Integration Based-on Business Process Driven Modelling*. Springer Berlin / Heidelberg, City, 2008.

[6] Zachman, J. A. A framework for information systems architecture. *IBM Systems Journal*1999).

[7] Zachman, J. A. The Zachman Framework. *,Ä¶ Institute for Framework Advancement. Available at: http ,Ä¶*, 3493561526198326243related:49MFyrKfezAJ 2007).

[8] Davenport, T. H. The coming commoditization of processes. *Harvard Business Review*2005).

[9] Carr, N. The end of corporate computing. *MIT Sloan Management Review*, 462005), 67-73.

[10] Carr, N. IT doesn't matter. *IEEE Engineering Management Review*2004).

[11] Benbya, H. and McKelvey, B. Using coevolutionary and complexity theories to improve IS alignment: a multi-level approach. *J Inf technol*, 21, 4 2006), 284-298.

[12] Chan, Y. E. Why haven't we mastered alignment? The importance of the informal organization ,Ä¶. *MIS Quarterly Executive*2002).

[13] Chan, Y. and Reich, B. IT alignment: an annotated bibliography. *Journal of Information Technology*, 222007), 316.

[14] Chan, Y. E. and Reich, B. H. IT alignment: what have we learned? *J Inf technol*, 22, 4 2007), 297-315.

[15] Burnes, B. Complexity theories and organizational change. *International Journal of Management Reviews*, 7, 2 2005), 73-90.

[16] McBride, N. Chaos theory as a model for interpreting information systems in organizations. *Information Systems Journal*, 15, 3 2005), 233-254.

[17] Sousa, J. *Information systems planning in WEB 2.0 era, a new model approach*. IGI Global, City, 2009.

[18] Selim, H. M. Critical success factors for e-learning acceptance: Confirmatory factor models. *Computers & Education*, 49, 2 2007), 396-413.

[19] Sun, P.-C., Tsai, R. J., Finger, G., Chen, Y.-Y. and Yeh, D. What drives a successful e-Learning? An empirical investigation of the critical factors influencing learner satisfaction. *Computers & Education*, 50, 4 2008), 1183-1202.

[20] Villiers, M. R. d. Three approaches as pillars for interpretive information systems research: development research, action research and grounded theory. In *Proceedings of the Proceedings of the 2005 annual research conference of the South African institute of computer scientists and information technologists on IT research in developing countries* (White River, South Africa, 2005). South African Institute for Computer Scientists and Information Technologists, [insert City of Publication],[insert 2005 of Publication].

[21] Graf, S. and List, B. *An evaluation of open source e-learning platforms stressing adaptation issues*. City, 2005.

[22] Popescu, E., Trigano, P. and Badica, C. *Evaluation of a Learning Management System for Adaptivity Purposes*. City, 2007.

Transforming Vocational Education in Slovakia

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***Abstract* - This paper aims at presentation and sharing of experience and practice from Slovakia on how the Networking Academy program is working in Slovakia as part of the Vocational education system of the country. The authors present the example of the Cisco Networking Academy model - which over the past fourteen years proved to be successful worldwide and resulted in continuous growth of participating students and teachers, who are willing to follow and acquire the newest IT computer networking skills. On February 28th 2011, the Cisco Networking Academy has enrolled its 1 millionth concurrent student for the first time and 2011 is the year of the Academy Evolution process not only in Slovakia but globally.**

I. INTRODUCTION

One of the objectives of a modern educational institution is to make sure that their graduates are not only able to apply ICT in their future jobs on the basis of the acquired ICT literacy but also that they are able to make use of these technologies as a tool and as an environment for the educational process itself. The current knowledge-based economy necessitates unprecedented flexibility of education, but also an effective offer of various options and solutions of knowledge acquisitions in various fields [6].

We live in an increasingly connected world, creating a global economy and a growing need for IT skills. 21st century jobs require 21st century skills, and for nearly 14 years Cisco has been leading the charge to impart these skills to the next generation of workers through Networking Academy program [1].

Global initiatives such as the Networking Academy program are significantly contributing to the formation of Vocational education systems in countries all over the world and Slovakia is not an exception.

II. BREAF HISTORY OVERVIEW OF NEW EDUCATIONAL MODEL DEVELOPMENT

The history of the Cisco Networking Academy model and the description of how the Cisco Networking Academy operates are presented in this chapter.

'Network' has different meanings (network infrastructure and social network). The Cisco Networking Academy provides a new approach on how to think about this phase in an eLearning community so as to utilize the most from the networking phenomenon. Describing how the program was developed and operating worldwide we would like to highlight three key factors, which are considered to be the most sensitive elements of a successful learning model, which helps students to discover new ways to learn, connect, share, collaborate and compete.

In 1993, the Cisco started to provide a cost-effective network infrastructure for schools in USA. However, it soon became obvious that schools also needed skilled network maintainers in order to effectively operate the network. Soon, however, another problem ensued: the school staff lacked time and resources. Eventually, it was found out that students themselves had a great interest in learning networking skills, and also that they sometimes even outperform the staff. This fact was the impulse that started the Networking Academy program.

In October 1997, Cisco officially announced the start of the Networking Academy initiative in 64 educational institutions in USA, and very soon, the program spread overseas. After more than 14 years of its existence, Networking Academy operates in more than 10 000 educational institution in over 165 countries [2] and nearly 4 million students participated in the program to date. From students in classrooms around the world accessing online activities, assessments and games to using their new IT and 21st century skills, to the 175,000 fans (and growing!) on Facebook, The global Networking Academy community leverages a cloud-based infrastructure to learn, collaborate and succeed in the 21st Century economy.

The program started to grow in Central and Eastern Europe [3] in parallel with the overseas and soon became even more dynamic concerning the number of participating institutions and students. The institutional framework of the network proved to be successful, institution either higher education or vocational schools found their education interest in joining the Cisco Networking community. The Cisco Networking Academy Program creates progressive opportunities for educational communities all over Europe. The program fosters local economic growth by developing and supporting technical education. The demand for a highly trained, technically perceptive workforce continues to grow with the increasing reliance on IP networks in everyday life, as well as the need for larger and more highly integrated network designs and implementations.

III. NETWORKING ACADEMY PROGRAM DESCRIPTION

The Networking Academy Program is an educational initiative that blends the e-learning web-based approach of providing centralized web access to curricula, lab exercises, exams, community features and other learning tools with instructor-led lessons, classroom instruction and hands-on labs. The Networking Academy can be implemented on secondary schools, technical schools,

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colleges, universities and community-based organizations.

A. Global Partnerships for an Educated ICT Workforce

Cisco Networking Academy partners with educational, nonprofit, business and government organizations, through a powerful public-private partnership model that makes it possible to accomplish together what would not be possible alone. Networking Academy and its partners work together to help students succeed during and after their studies. Cisco supports its educational partners with the following services:

- Internet access, Online curricula and materials at no cost to nonprofits
- Discounted networking equipment for hands-on labs
- Cost-recovery options for instructor training
- Innovative tools and resources to help students build professional ICT career pathways

Cisco has developed strategic collaborations with educational institutions, private sector, nonprofit organizations, and government agencies around the world. These relationships expand the professional opportunities of students and schools, and reach out to disadvantaged and at-risk populations.

B. Well-functioning Institutional Framework

Willingness to make things happen is the second critical element of any education development program. One of the main strengths of the Cisco Networking Academy is the motivation of the management and the instructors participating in program development. Human resources are committed because they share a common professional attitude that networking skills are important to raise competitiveness both in education and in economy. Cisco technology is not only subject of this learning environment but also used as the main tool of learning and communication, which shows that ICT is the core element of continuous personal and community development. Networking Academy members, managers, instructors, students use Cisco technology (emails, WebEx, Video-conferencing, Telepresence) when changing information. This kind of 'learning by doing' method is used all over the community, and helps all participants actively participate in a hidden lifelong learning process.

The Networking Academy program uses the "train-the-trainer" model of preparing qualified instructors for the individual courses.

C. Professional Learning Content – Networking Academy portfolio

Cisco as a networking company provides the eLearning environment and the digital content to be taught over the world. The Networking Academy Program is an educational initiative that blends the e-learning web-based approach of providing centralized web access to curricula, lab exercises, exams, community features and other learning tools with instructor-led lessons, classroom instruction and hands-on labs. The Networking Academy can be implemented on secondary schools, technical schools, colleges, universities and community-based organizations.

The content taught in the Networking Academies is organized into so-called Curricula or Courses. Presently, the complete portfolio encompasses these courses:

- IT Essentials: PC Hardware and Software
- Cisco Certified Network Associate (CCNA), currently in two different versions: Discovery and Exploration
  (4 courses for each version)
- Cisco Certified Networking Professional (CCNP)
  (3 courses)
- CCNA Security course

D. Learning Management System (CAC - CISCO Academy Connection)

As the Academy program expanded, Cisco needed a learning management system to deliver curriculum, instruction, and assessment to Academies everywhere. The Cisco Academy Connection (CAC) is the centralized Learning Management System (LMS) website that provides the e-learning aspects of the studies in the Networking Academy. Access to this website is protected by the username and password that can be created only by instructors or other privileged persons within the system. Technically, it is a proprietary LMS created especially for the needs of Networking Academies, and its source codes or its installation package is not released to the public. The CAC provides centralized and controlled access to these learning tools:

- Classes, Curricula and Lab Books
- Exams and Gradebooks
- Special resources for students and instructors & Networking Academy Help Desk

<u>Classes</u>

In order for a student to attend training, he or she must be enrolled in a class in which the respective course is taught. A class is described by its name (can be arbitrary), course, duration, instructor and other supplementary data. After a class has been created, students can be enrolled into it.

Student enrolled into a class is given access to the respective curriculum, labs, exams and his personal gradebook that tracks his score in that class. The grades are given for taking the chapter (or so-called module) exams, the Final Exam, the Skills Exam and potentially for a number of other activities. An instructor has always the possibility to define his own custom scores in addition

to those already defined. The weight of individual scores as they sum up to the overall score can be redefined as well.

Classes and lectures can be delivered in two ways, either in-person or remotely, via a so-called Blended Distance Learning (BDL). The BDL approach combines the remote lectures with in-person training.

For each student, the CAC maintains a complete list of all classes attended by that student, together with the Gradebook for historical purposes. As a general rule, the curriculum is always available online as a web-based course; however, it is not downloadable for off-line storage to students.

Curricula and Lab Books

The curriculum is the main self-contained source of information necessary to proficiently pass the course. As a general rule, the curriculum is always available online as a web-based course; however, it is not downloadable for off-line storage to students.

The curriculum is internally divided into modules (a self-contained single-topic lecture), and each module consists of variable count of chapters. The curriculum format is either a combination of HTML and Adobe Flash content, or in the newest versions the curricula are multimedia-rich. They make frequent use of video, graphics and audio content, animations, interactive activities and quizzes, all tailored to reinforce the student's knowledge.

Many concepts are further illustrated by a curriculum directly providing links to prepared Packet Tracer files. PT is the network simulation software created by Cisco and available for free to Networking Academy students and instructors. The PT allows to emulate network topologies from a predefined set of devices (routers, switches, access points, servers, etc.), to configure them almost in the same way as real Cisco devices are configured, and to observe the details and inner workings of networks in "slow-motion". The curricula are also equipped with indexes, built-in quizzes and glossaries. In conformance with Section 508 of the U.S. Rehabilitation Act of 1973, various curricula are also available in so-called accessible format for people with disabilities.

Currently, the default language for all curricula is English. The IT Essentials and CCNA curricula are also being translated to Arabic, French, Russian, Simplified Chinese and Spanish.

With each curriculum, a corresponding Lab Book is prepared that contains tasks and exercises to practice and reinforce the students' knowledge gained throughout the course. The Lab Book is usually provided in two forms: a Student Edition and the Instructor Edition including reference solutions of the tasks. Each module of a curriculum contains references to individual assignments in the corresponding Lab Book, thereby directly leading to practical activities required to master the topic.

The curricula and Lab Book contents are developed and maintained by Networking Academy Curriculum Development Team at Cisco. No direct external changes to the materials are possible; however, the instructors have a way how to suggest improvements using the Help Desk service. This way it is ensured that a curriculum is the same wherever it is taught. Also, the changes to the curriculum are tracked and controlled centrally.

Exams and Gradebooks

Almost every module in a curriculum has a corresponding exam associated with it that can be activated for students and graded after a student has taken it. The exams consist of around 20 questions each, displayed in a web form with selectable answers. The questions can be either Multiple Choice Single Answer (MCSA) or Multiple Choice Multiple Answer (MCMA). In the case of MCMA question, the correct number of answers is always indicated in the question. The scoring rules are fairly simple: a predefined count of points for each correct answer, zero points for each incorrect answer, and zero points for the whole question if more answers were selected than required. There are no negative points. Also, there are no answers written by students themselves. Besides the module exams, each course contains a so-called Final Exam that is significantly larger (around 50-60 questions) and covers the whole course. The Final Exam is one of required exams for passing the course. The types of questions and scoring rules are identical to module exams.

As a special requirement, each course contains a so-called Course Feedback which must be completed by each student. While in a form of an exam, it is not really an assessment of student but rather a questionnaire of how the students perceive the quality of study materials, learning environment and their instructor in particular. Results from the Course Feedback are anonymized and available to both Cisco and the instructor as a feedback about the quality of the delivered lectures.

All student exam grades earned during a course are stored in detail in the class gradebook. The gradebook also contains scores earned for the Skills Exam (a practical assignment solved as a part of final examination at the end of the class) and possibly other scores as well. The instructor can redefine the weight of each score present in the gradebook as it sums up to the resulting weighted score. Thereby an instructor is free to define what scores have a greater impact on the resulting score of each student.

The gradebook also provides a way to check on individual students' responses to an exam and to see the correct answer. Moreover, for each exam, a statistical breakdown of student success in each question can be generated, both for the particular class and for the Networking Academy world-wide. This provides a fine insight which questions appear to be problematic for majority of students, and vice versa.

Special resources for students and instructors

There is a multitude of resources available for instructors teaching a particular course or maintaining an academy. For majority of courses there are PowerPoint presentations prepared that highlight the key concepts and points in each module of a given curriculum. Instructors are free to use and change these presentations to suit their needs.

Each course may have another tools associated with it. Particularly, for the new CCNA Discovery and Exploration courses, a CD/VMWare live image is prepared that contains an entire server operating system with various network services already preset and ready to use. This server image greatly simplifies the teaching of CCNA courses in academies that do not run their own network servers. Furthermore, as a part of CAC, there is a FTP repository of shared content. Using this repository, instructors may share their own presentations, lectures, lab assignments, skills-based assessments and any other relevant materials.

Both students and instructors have access to a section of CAC called Forums&Chat which contains a number of moderated discussion boards.

E. Course alignment with industrial certifications

The today's companies are very interested in having a common way to assess and measure the professional knowledge and skills of their employees. Industrial certification of persons provided by a disinterested third party is very often the choice.

Cisco has a complex system of industrial certifications for various network industry specializations and knowledge levels. While the Cisco certification portfolio is vast and diverse, the most requested certifications can be divided into three groups according to their complexity: the introductory Associate level, the advanced Professional level and the highest Expert level. Depending on the level and the specialization of the certification, it can consist of one or several certification exams that must be passed before the certificate is awarded. Each exam is a paid service, and the certificate itself expires after 3 years. In order to stay certified, the person must either recertify in the current level, or pass an exam that extends the certification to a new specialization or a higher level.

The contents of each course available in the Networking Academy are closely aligned to the respective Cisco industry certification, covering all knowledge areas necessary to pass the certification exam(s).

The most popular certifications of today are CCNA and CCNP that are completely covered by the CCNA and CCNP curricula. Currently, the CCNA certification can be obtained by passing one composite or two partial certification exams. The CCNP can be obtained by passing another three or four certification exams, depending on their scope.

The certification exams are provided by specialized testing centers that are completely independent of the Networking Academy program.

IV. ACADEMY EVOLUTION IN SLOVAKIA

Over the past 12 years, Cisco Networking Academy has grown to over 10,000 academies and more than 1,000,000, students to become the "world's largest classroom". Cisco Networking Academy must keep up with the times and prepare for the future generation of learners. The program is moving from a instructor training and support model to a global resource network made up of public and private sector organizations offering a variety of resources to academies, instructors and students.

The Academy Evolution process is a union of technology and program process enhancements designed to help academies thrive and students meet their goals. After over 14 years of global presence of the program, these huge changes within the program are expected to bring the community a new starting point where new roles and rules are defined.

This process also includes redefinition of the whole partner model. The old model consisting of Cisco, CATCs, RCNAs and LCNAs (Figure 1) is rapidly changing. These changes are needed as this model is very limited in possibilities for cooperation among the institutions and scalability.

Figure 1. The old NetAcad partner model

The new NetAcad partner model (Figure 2.) is bringing new opportunities to the community. The most relevant expected benefits are: closer relationship between Cisco and Academies, specialized institutions, more effective and sustainable partnerships, recognition of increased community role.

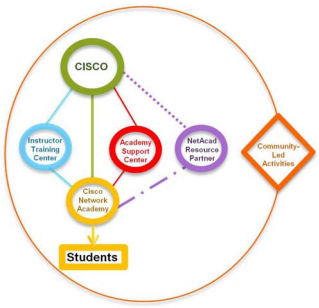

Figure 2. The new NetAcad partner model

The new partner model consists of the following subjects: Cisco, Academy Support Center, Instructor

Training Center, NetAcad Resource Partner and Cisco Network Academy. The roles of these subjects are defined as follows to support the idea of cooperation and community led activities.

Cisco

Cisco is expected to develop and deliver teaching and learning content, systems and tools and to monitor and manage quality.

Academy Support Center

The Academy Support Centers specializes and excels in supporting academy sustainability and excellence: on-boarding, training administrators, critical communications and any other support required by Academies.

In Slovakia, the Technical university of Kosice, former RCNA, as the only one, has applied for this role and was successful. It is now providing support to the whole community in the country.

Instructor Training Center

These centers will specialize and excel in preparing and developing academy instructors by providing them trainings and instructor professional development opportunities.

There are three ITCs in Slovakia, starting their activities from September 2011. All these ITCs (Technical university of Kosice, University of Zilina and Slovak University of Technology) are former regional academies and are experienced in instructor trainings. All instructor trainers working there have successfully passed the Instructor trainer qualification process and are now eligible to train academy instructors.

NetAcad Resource Partner

Resource partners are expected to enable more contributions to academy success: equipment donations; internships; job placement; scholar-ships; council coordination and marketing support.

At this time, there are seven active resource partners in Slovakia providing services and support to NetAcad community in Slovakia. These partners are: Technical University of Kosice, Slovak University of Technology, GTEC Institute, Training Institute elfa, ALEF NULA, ADECCO, T-Systems Slovakia and Slovanet.

Cisco Network Academy

Academies teach students academy curriculum and 21stcentury skills to succeed in the global economy and on the job market.

There are about 70 academies in Slovakia, providing NetAcad courses to students at both the secondary school and university levels, and spread evenly in all regions of the country.

As mentioned in this paper, the main goal of all these changes is to provide the community a new model that reflects the global changes in education and the growing need for computer networking specialists. The process of pilot testing of this new model was launched in Slovakia in September 2011. The feedback provided by this pilot testing will influence the global Academy Evolution process.

V. NETACAD IN SLOVAKIA

The NetAcad program has during its 12 years of presence in Slovakia achieved many milestones that the community can be proud of. Instructors and students have actively participated in a number of national and international events and activities and their success proves the quality of the program. The author would like to mention two important activities from the past period.

The former RCNA at the Technical University in Kosice, Slovakia (TUKE) belongs to leaders in implementation of new ICT and innovative methods into the educational process in Slovakia. This academy, as one of the first academies in the CEE & CIS region, has in July 2010 presented its Telepresence room and started its cooperation with National Lambda Rail (NLR), US research network, by connecting more than 60 US Telepresence rooms at universities and educational institutions with the Technical University in Kosice.

Discussions between the representatives of TUKE and network of US schools (K12) from the Paradise Valley Unified School District, Phoenix, Arizona" (PVSCHOOLS) during the summer 2010 resulted in a joint project. Starting on 4th September 2010, a pilot CCNA 1 Exploration course for ten participants from the PVSCHOOLS, teachers and technical staff from 5 US localities, via Telepresence was realized. The instructor of the course, Peter Fecilak (TUKE), has in cooperation with his colleagues from the RCNA TUKE prepared a unique teaching methodology for this course based on Telepresence considering the specific conditions of the course (nine hours of time difference, language barrier, missing blackboard in the Telepresence room – instead of which a computer with touchscreen – Tablet PC is used, etc…). The instructor has defined a time table for the course, system o presentations and exercises, internal communication for instructors and students, grading and other organizational aspects for the course.

For the further development and progress in the NetAcad program within the Academy Evolution process, partner cooperation, sharing experience and student and teacher mobility can be key. Networking technologies and unique study programs based on NetAcad are creating ideal environment for the student and teacher mobility among educational institutions that are part of NetAcad. The recently introduced National Scholarship program of the Slovak government provides the right opportunity, http://www.scholarships.sk/en/.

The Ministry of Education, Science, Research and Sport of the Slovak Republic approved new terms and conditions for providing financial support under the National Scholarship Programme for the Support of Mobility of students, PhD students, university teachers, researchers and artists: supports study and research stays

at universities and research organizations. It supports two-way mobility — of foreign scholarship holders to Slovakia as well as of Slovak scholarship holders abroad. Scholarships cover living costs related to the scholarship stay. Slovak scholarship applicants may also apply for a travel grant.

The NRP, elfa, s.r.o., is in cooperation with the ASC at the Technical university of Kosice providing NetAcad community in countries that are eligible for this support help and assistance in searching for partner institutions in Slovakia, members of the NetAcad community for cooperation in the project.

VI. NETACAD IN NUMBERS

The Networking Academy during its more than 14 years of history has allowed many students to participate and graduate in the program and its courses. The Table I. below shows examples of current statistics from selected countries. Students represent a distinct count of students that were in a class in session within the past 12 months.

Country	Population	Active Students	Population Penetration
Czech Rep.	10 190 213	7 700	0,1997%
Hungary	9 976 062	4 645	0,1701%
Poland	38 441 588	18 381	0,1788%
Romania	21 904 551	11 338	0,2121%
Russia	138 739 892	5 831	0,0145%
Slovenia	2 000 092	372	0,0673%
Slovakia	**5 477 038**	**5 093**	**0,3751%**

Table I. Statistics from selected countries

Table II. shows the cumulative number of students that represents a distinct count of students that have participated in the program since inception and percentage change in the number of students in FY 12 compared to FY11.

	FY12	FY11	
Country	Students since program inception	Students since program inception	%
Slovakia	**20 547**	**18 004**	**14,12**
Romania	**46 464**	39 838	16,63
Czech Republic	**20 346**	16 299	24,83
Poland	**68 719**	57 966	18,55
Hungary	**16 974**	14 000	21,24
Slovenia	**1 347**	1 103	22,12
Russia	**20 081**	16 560	21,26

Table II. Cumulative number of students

More global key statistics:

- 1 million online assessments delivered monthly
- 100 million online assessments delivered to date
- 272,000 Facebook fans, and it is growing daily [4]

The presented numbers show that the popularity of the program is growing among the students and their number is higher and higher every year. This encourages the community to be more active and involved in the whole process of Academy Evolution as it is understandable that global education programs such as Networking Academy program can provide the vocational education system quality basics for the development of study programs both popular among students and welcomed by companies, potential employers.

VII. CONCLUSION

Cisco Networking Academy has become the blended learning project of choice for delivering networking-oriented courses in vocational and university IT education. Being one of a few ongoing and successful collaborations between business and the educational sector at such a large scale and, it also has the unique notion of being something that has a real impact and importance for students and their career aspirations. Overall, Cisco Networking Academy has managed to create an environment which motivates both the students and instructors to continuously improve and more knowledgeable on their joint learning journey.

From the perspective of Central & East Europe region the Networking Academy program plays very important role in the educating of IT specialists – Networking professionals for the future. In many countries of the region the program is recognized by governmental entities and integrated to the education system [6].

REFERENCES

[1] Cisco Networking Academy Program, http://www.cisco.com/go/netacad

[2] World's Largest Classroom Campaign, www.cisco.com/go/wlc

[3] Jakab F., Czacharowska-Rybkowska A., Beni G., Kniewald K., Schwertel M.: A Passport to Opportunity – the Learning Model of the Cisco Networking Academy, Innovation in Learning Communities - EDEN 2009 Annual Conference 10-13 June 2009, Gdansk, Poland, 8pp (Book of abstracts), full version on CD (6p.)., ISBN 978-963-87914-2-9

[4] Facebook: www.facebook.com/cisconetworkingacademy

[5] P. Paluch, M. Kubina, P. Segec: The networking academy program: Current state and future trends. 8th Int. Conference on Emerging eLearning Technologies and Applications, ICETA 2010 - Conference Proceedings, Stara Lesna, 28.-29.10.Kosice, elfa, s.r.o., pp. 383-388, ISBN 978-80-8086-166-7

[6] F. Jakab: World's Largest Classroom. International Conference Interactive Collaborative Learning – ICL 2011, Piestany, Slovakia, ISBN 978-1-4577-1746-8, CD, 666-671pp., invited key-note

Academia-industry link progress in knowledge-driven economy

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Abstract—Science and technology will improve the quality of life of future generations. A knowledge-driven economy goes along with high-tech companies. University of Miskolc has information about industry products, marketing and development trends, feedback on graduates' competences, the quality of teaching, improves curriculum, teaching materials and methods, implements its research mission successfully by joint projects, provides graduates for the knowledge-driven economy, reduces the height of the wall between academia and industry. Industry employs graduates meeting up-to-date requirements, raises science and technology application in new products. It employs new PhD-degree holders, generates and mainly transfers, applies and disseminates new knowledge.

I. INTRODUCTION

In the early 2000s the European industry was not what it once was: although many industries were still to be found in Europe, but other economic blocs, such as Asia, were establishing themselves as the world's principal production sites, aided in part by a less costly workforce and the opening up of world markets.

European leaders therefore decided to stake the EU's future on something in which it had always excelled: science and technology. Knowledge would thus secure the future of the Old World, through the creation of a knowledge-based or knowledge-driven society rooted in higher education, innovation and research: these components so fundamentally inter-dependent that they came to be known as the *knowledge triangle*. "Knowledge Triangle" has three pillars: higher education, research and technological development (RTD) and innovation (i.e. the share of inventions that actually reach the market).

Universities' core mission will be therefore to educate graduates and to ensure they are equipped to engage in the process of new knowledge creation and the dissemination and application of knowledge. The speed of innovation will increase affecting social and economic processes; they have to be proactive to plan future scenarios. In future, Europe's added value would thus be based on the new knowledge created within the European Research Area (ERA), a source of jobs and profit.

In the year 2000 Europe produced a third of the world's scientific knowledge and occupied a leading role in many fields – aeronautics and telecommunications, for example – however its global research investments, both public and private, were far below those of its principal rivals, namely the USA, Japan and the "Asian tigers". This comparatively low level of investment was not uniform. In the new Member States, where resources are often fewer, the sector is sometimes precarious. Thus RTD systems in Europe are struggling to break free of the national framework [1].

The "fifth freedom" – the freedom of knowledge across borders within the EU – will become integrated into the existing rights of people, capital, services and goods to move freely. By 2030 an open, fair, genuine single market for innovation will pull new ideas, talent and investment from around the world [7].

For maximum economic and social impact, strategy for information society technologies concentrates on the future so-called convergence generation. This involves integrating network access and interfaces into the everyday environment by making available a multitude of services and applications through easy and "natural" interactions.

In March 2000, the Lisbon European Council adopted the development of the information society as a key priority in the strategy to make Europe "the most competitive knowledge-based society in the world".

This took practical shape in the e-Europe 2002 initiative, to promote "the information society for all": a cheaper, faster and more reliable Internet; stimulation of Internet use, and investment in people and skill.

The challenges facing the European economy have not changed: increasing productivity in response to the ageing population; confronting international competition; preparing for the increasing scarcity of natural resources, starting with fossil fuels.

The EU's sustained productivity growth depends largely on policies to stimulate science and technology and innovation systems. A high level of educational attainment is also positively correlated with a productive, skilled and adaptable workforce and is a precondition for lifelong learning as well as for higher labor-market participation rates.

University of Miskolc (UM) with its three Engineering Faculties, four Engineering PhD Schools, Engineering Departments and 400 academic staff members together with over 200 contracted industries/firms contribute to the knowledge-driven economy.

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II. Science and Technology – and What the Europeans Think About

A. Science and technology

Science and technology pose one of the greatest challenges facing the Union today. Advances in this field are crucial for its political and economic future if it is not to fall hopelessly far behind the USA and the "Asian tigers" in the relentless technological race of the modern world. To this end it must mobilize its true wealth: the creative spirit and energy of its people. This potential is the basis for its scientific strength and competitiveness, on which rests the high technical and scientific quality of its industry and agriculture.

The goal set in Lisbon thus remains "the appropriate framework for encouraging growth and jobs", especially at a time of crisis, as the European Council repeated on 20 March 2009. The EU is not alone in making this analysis. On 27 April 2009, *President Obama* declared that he had set the goal for the United States of investing more than 3% of GDP in research to prepare for the future. "The challenge, in short, is nothing less than our salvation", he concluded. That leaves the matter of the method to apply in implementing the Lisbon strategy. This is essentially threefold: • to increase the research effort to reach 3% (2% from private financing and 1% from public financing); • to facilitate exchanges between the private and public sector; • to encourage the creation of skilled jobs and high-tech companies. In 2007 just 1.85% of GDP was invested in research in the EU-27, precisely the same level as in 2000.

The reason the ratio has stagnated overall in recent years is that economic growth was strong prior to 2008 and investment in research grew less quickly than the wealth produced. The fall in Europe's GDP since 2008 has the automatic effect of producing a relative increase in the research effort, while Member States maintained their scientific budgets and companies their RTD budgets. 23 of the 27 EU countries, representing more than 98% of the EU's public investment in research, are following the Commission's recommendations to respond to the crisis by investing in research. Just two Member States facing a very difficult financial situation were unable to do this [11].

The *private sector* should seize the new opportunities to work with the public sector and to develop innovative products. This is the ultimate test of the success – or failure – of the Lisbon strategy. One figure sums up the situation: 49% of European researchers are employed in the private sector compared with 80% in the United States and 68% in Japan. Private sector research must be strengthened and its results converted into added value if the EU is to create a genuine knowledge-driven economy, and it is on achieving this that the post-2010 effort and reorientation must focus.

Economists stress that one of the obvious reasons for Europe's difficulties in converting its scientific excellence into economic growth lies in the nature of its system for protecting intellectual property. Registering a patent remains much more expensive in Europe than in the rest of the world. To protect an invention, an industrialist spends up to 10 times as much in the EU as in the United States, and 13 times as much as in Japan. The costs of maintaining a patent are even higher, often acting as a deterrent for small businesses that are forced to cede their innovative technologies. This cumbersome system for obtaining intellectual protection is not new, however, and in recent years European leaders have taken a number of steps to correct it [8].

B. Popularity ratings of Europeans on science and research improvement

The Eurobarometer gradually measures and analyzes EU-27 people ratings on various impacts. 69% of Europeans (EU-27) believe that the applications of science and new technologies will make work more interesting. This statement met with very broad acceptance in all the countries.

TABLE I.
Popularity Ratings on Quality of Life in Percentage

Quality of Life Indicators	Agree	Disagree	Do not Know
For most people today, their quality of life is better than it was for their parents' generation	85	14	1
The next generation will enjoy a better quality of life than we do now	58	34	8
Developments in science and technology have improved the quality of life for your generation	87	10	3
Science and technology will improve the quality of life of future generations	78	15	7

Source: Eurobarometer (2005-08), structured by the authors

Science and technology will improve the quality of life of future generations; approval rates of Estonia is 92%, Slovakia 83%, Hungary 82%, EU-27 average is 78%.

TABLE II.
Optimism of Europeans regarded expected technological progress

Technological progress areas	Contributions to technological progress to quality of life in percentage			
	Improvement support (optimism)	No effect (scepticism)	Will deteriorate (pessimism)	Do not know (uncertain)
Computers and information technology	79	11	6	4
Solar energy	77	14	3	6
Wind energy	74	16	3	7
Mobile phones	58	23	15	4
Biotechnology/ Genetic engineering	53	13	12	22
Space exploration	44	35	9	12
Nanotech	40	13	5	42
Nuclear energy	32	18	37	13

Source: Eurobarometer (2005-08), structured by the authors

Nobody denies that science opens the door to knowledge. But what is the limit to the world's intelligence? Will it one day be able to explain "everything"? The statement made is the following: "one day science will be able to give a complete picture of how nature and the universe work". One in two Europeans

believes that will be the case. The most optimistic are citizens in Southern Europe – the Maltese (73%) and the Greeks (70%) – while the people of Northern Europe are the most sceptical: the Finnish (58%), the Swedes and the Dutch (54%).

While the IT revolution and the prospects of renewable energy sources (solar and wind power) draw *strong support*, those optimistic about the biotech sector and genetic engineering enjoy only a slim majority. With regard to the biotech sector in particular, European citizens are divided in their reaction, between *scepticism* (13%), pessimism (12%) and "don't know" (22%). In contrast, a large proportion (35%) of those surveyed, remain sceptical of the benefits of space exploration although it is indispensable for emerging technologies like mobile phone, computing science and internet. The response to nanotechnologies was the most uncertain (42%), while nuclear power had the largest group of opponents (37%) probably due to Chernobyl and other crises.

III. European Research Area as a Solid Pillar of Knowledge-Driven Economy

A. State-of-the art of the European Research Area

The objective is to find ways of overcoming the continuing fragmentation of European public research. The European Research Area (ERA) concept encompasses three interlinked areas:

- Progress towards a new "*internal market*" for research, in which scientists, technologies and knowledge can move freely;
- Real coordination of national and regional research programs, at the European level, on the basis of common priorities;
- The launch of infrastructural initiatives introduced and financed simultaneously at European, inter-governmental and inter-regional level.

The fragmentation of public research makes Europe unattractive to businesses wanting to invest in RTD. These companies often find it difficult to cooperate or form partnerships with research institutes, in particular from one country to the next. European companies are investing more in RTD in the USA than US companies are in the EU, and *the transatlantic balance of investment deficit is widening*.

B. Knowledge-driven economy and framework programs

European research is torn between two poles. On the one hand there is the desire to 'see big' and encourage partnerships between the continent's largest and most imposing names in science and technology, in order to *achieve a 'critical mass'* and/or structure the European Research Area. But on the other hand there is a concern not to overlook smaller players and the vital innovative potential to be found in SMEs. For this first pole, FP6 was given new financial instruments with which to support not only traditional targeted research programs, but also so-called *'integrated' projects* and *'networks of excellence'*. The aim of the *networks of excellence* was to constitute a framework of high level scientific and technological networks, and put an end to the fragmentation of human and material capacities which curtails the European Research Area.

A knowledge-driven economy goes along with high-tech companies. It is high-tech that generates most of the private investment in with the ERA is so sorely lacking. However, the structure of the European economy is changing, with a relative deindustrialization and a switch to the services sector. This is not yet generating much research, less than aeronautics, the motor industry or energy – sectors in which the EU retains a leading place – and above all the biotechnologies and information and communication technologies. It is in these last three fields that the EU is being left behind, particularly by the United States, where a lot of biotechnology start-ups grow into major pharmaceutical companies with huge RTD budgets. In Europe they remain small businesses. The same is true in the Internet sector. The EU is still waiting for its Genentech or its Google.

Recent years have seen increased research in the manufacturing industry and services in Europe. But the decisive battle is being played out in the high-tech industries.

Around 50 000 or *two thirds of the players* involved in the European programs *come from the public networks* – universities, higher education institutions and research. Of the 435 000 researchers working in the 4 000 higher education institutes known to the EU authorities, an estimated 1 in 10 benefits to one degree or another from European financing.

This predominance of the public and academic sector should not, however, be allowed to mask a profound change that is taking place as European research policy opens up towards the private sector. As integrated projects grow in size, some of Europe's leading industrial players are increasingly involved in strategic sectors like ICT, nanotechnologies, aviation and space.

IV. Higher Engineering Education Serves Knowledge Creation and Transfer

"Engineering is directed to developing, providing and maintaining infrastructures, goods and services for industry and the community" (SARTOR). The ideal of the university is the open, digitally networked, knowledge institution working in co-operation with industry and society. Some further clustering of universities is expected to gain leadership in one or more emerging fields. A new EU reform will start with this "open knowledge institution": open to industry, politics and society at large. University career structures would change, so that excellence, not time served, is the criterion for advancement in teaching and research. Striving for excellence is the only choice Europe has. The ideal mechanism is when the EU institutions will become the "gold standard" to which all may aspire, but only the best succeed.

The EU's higher education performance indicators in terms of research (university ranking) or in terms of educational achievement are at 70% or less than in the United States [10]. University ranking system is to be somewhat mono-dimensional (focused primarily on research) on the other hand, and do not fully cover dimensions such as teaching and learning quality of knowledge transfer. Such mono-dimensional systems use indicators that discriminate only among the most research-

intensive institutions and hence do not always provide useful feedback on ways forward for the majority of European universities. The ability of Europe to attract foreign brains is also less effective than in the US.

The untapped reservoir of talented young people, especially in the newer Member States, is probably the EU's greatest underexploited asset. A young graduate will be able to earn a degree in one country and easily move to another to work and teach; indeed, a growing population of researchers will earn PhDs with a truly European dimension, obtained by working in more than one Member State (Euro-PhDs).

Higher education and research systems cannot be changed within short term and it is sometimes several years before the results of reforms are evident. Most Member States have introduced legislation to make universities more autonomous and thus able to enter into cooperation with the private sector. Work is currently in progress to develop a European system for the international comparison of universities with a wider range of criteria than the famous Shanghai classification. This should make it possible to make a better appraisal of the international performance of European universities [2].

V. Academia-Industry Link Progress

A. Challenges

The walls between industry and academia are still too high; mobility of staff between them is low. Europe's past failures at innovation are true, thus a robust whole-business model for researchers and industrialists and an integrated innovation system in order to strengthen the "put-through" capacities are needed [8]. When large international companies look for a site a research facility, they look not only for major markets, but also for a strong research and competence base. Yet to date, the fact was ignored that proximity of competences matters.

The average rate of *industry participation* within the 7th Framework Program (FP7) is around 30%. The participation of industry is a question of the challenges faced by different sectors. When objectives of research are very important for European industrial competitiveness, they should be industry-driven. Often projects do not respect that priority. They are coordinated by universities or other research organizations which are collecting support from industrial corporations. The opposite situation was more frequent in the first Framework Programs. Throughout Europe industrial participants say that they are not in the driving seat anymore. The prime question is the role industry can play in the implementation of the European Framework Programs.

The root of the university-industry relationship in Europe is that the EU does not have many strong centers of excellence, like Massachusetts Institute of Technology (MIT), Berkeley, Stanford, and Columbia in the USA, which are leading academic research institutions. Industry cannot find these kinds of partners, but the EU will establish a separate European MIT, the new European Institute of Technology (EIT) in Hungary [9] and will reconcile the partners with the different approach and attitudes to public-private partnerships in each Member State. The EU simply must be able to use the best universities in Europe, to start strengthening them and creating an incentive structure where they would have a genuine interest in collaborating with industry. This is the culture that Europe is lacking.

In the training and careers hierarchy at the starting blocks, girls do well. In 2005 they made up more than half the university population. 59% of European female students EU-27 – all disciplines together – went on to complete their basic courses (bachelor, masters, etc.) as against 41% of male students. But at the top level (grade A which stands for the highest grade/post at which research is normally conducted) in universities and research institutions, women have just one representative (15%) against six male colleagues (85%).

The European academic world has around 15% of women professors. Women were best represented at this level in Romania (29%) and Latvia (26.5%) and were least present, at around 9%, in Germany, the Netherlands, Austria, and Belgium. The percentage of 'Grade A' (EU-25) also varies according to area of specialization, with feminization strongest in human sciences (23.9%), social sciences (16.6%) and medicine (15.6%).

According to an OECD report, employment of human resources in science and technology (HRST) "continues in all countries to progress much faster than overall employment, at an average rate of 2.5% a year in the USA, and 3.3% in the EU. This acceleration is due mainly to the increase in female employment and the expansion of the services sector".

According to Eurostat, *'qualified female knowledge workers' are to be found principally in the high knowledge intensity services* – which welcome the majority of higher science and technology (S&T) graduates, 44% of women and 56% of men. On the other hand, in the high tech sector with a more specifically industrial vocation, which at European level employs over 8.7 million scientists and engineers, only 29% of 'graduate' jobs are held by women. At this level, their presence tends to stagnate, while the proportion of men is growing by 2% a year.

In 2005, 43% of the 88 000 doctorates acquired in European universities were awarded to women – an increasingly large number, and quite impressive compared with the figure of just 25% in Japan. Since 1999, the growth in female doctorates (7%) has been well above that of the men, estimated at 2%. The countries posting the highest proportions of women reaching PhD level are, in particular, those of Central and Eastern Europe, with their strong traditions of scientific gender mix.

In terms of specializations, life sciences come well in front, and *engineering trails the pack*. The weakness of this latter figure is not, however, comparable everywhere: 33% of Hungarian women PhDs, and almost 25% of Finnish and French ones, are to be found in the *'engineering'* segment, as against just 7% in Germany.

Around 30% of all *active researchers* in Europe are women. They account for more than a third of the grey matter resources of universities and other higher education institutions and of the research carried out in countless public laboratories. On the other hand, they are still largely 'left on the shelf' by private labs, where one finds only one woman for five men. Differences from one country to the next can, as is often the case, be quite large.

The former communist countries are where the greatest proportion of women are employed in scientific structures, filling between 30% and 50% of jobs in the RTD sector compared with between 20% and 35% in the EU-15. In

terms of research budgets, the picture is the reverse. The greater presence of women in the new Member States is often accompanied by very limited resources.

B. Academia-industry link progress by UM

UM-industry link [4], [5], [6] is improved in 19 main categories:

1. 100 to 170 *industry personnel* of over 200 contracted industry/firms are involved in joint design and evaluation of engineering curriculum, monitoring of engineering courses, organization and evaluation of industrial practice of students and graduates if and when needed.
2. *Gaining industry experiences in industry* criterion targets mainly young lecturers by involving them in joint university-industry projects, strengthening academia-industry link, short-term industrial practice in summer-time, their contribution to courses run by industry personnel in industry with the involvement of 12 to 15 young lecturers a year and leading industrial practice of 200 to 400 students, both in this country and monitor 20 to 30 students abroad.
3. 30 to 50 joint research and technological development (RTD) *projects* are initiated and implemented each year in all engineering science areas attributed to UM.
4. *University-attached research centre* on applied chemistry, a Regional Knowledge Centre on Logistics and Material Science and Uni-Flexys Ltd dealing with innovation and projects with industry are working; 60 to 90 academic staff participates in research carried out by these units and 15 to 25 researchers deliver lectures or conduct laboratory and other engineering practice for students of UM each year.
5. Close co-operation is being established with respective *research laboratories* working in the region: "Z. Bay" National Research Institute for Logistics and Production Engineering and Nanotechnology Research Institute. Both researchers and academic staff cross the border to participate also in joint research project and conduction of courses run at UM.
6. 6 to 9 *joint research projects* a year are launching together with few EU and third country universities, mainly Switzerland, Ukraine, Russia, Canada, the USA, Turkey and/or few enterprises mainly in mechanical and electrical engineering, logistics, information technology, material science and technology, earth science and technology.
7. 10 to 14 industry personnel are involved in *European education and research projects* based on their knowledge in manufacture, research, management and the vision of respective engineering fields.
8. 20 to 28 *industry leaders' involvement in final examination* of UM students, provide feedback on students' knowledge, skill and competences. Tutors and industry supervisors/referees evaluate the theses for graduation and submit their joint opinion to the final examination board appointed by the Rector with the involvement of industry leaders and specialists as well. All components of final examination like the results of basic, fundamental and applied engineering courses and the thesis after providing different weighted factors to each component give the final result of the diploma/degree. This symbolizes the knowledge, skills, capability and competences of the graduate in one rank dedicated excellent/outstanding, very good, good and satisfactory marks written in the diploma/certificate. This is the real output of higher engineering education, the engineer of the 21st century.

The *Final Examination Board* has a particular duty to select the best three or four diploma theses between each group of 20 or so prepared and presented by the students of UM. The respective theses along with the evaluation of the Board will be submitted to the Institutes of Electrical, Mechanical and other Engineering of Hungary.

9. *New 'Robert Bosch' Department of Mechatronics* was initiated by the German Bosch GmbH Industry with financial aid at the University of Miskolc and its operation started on 1 July 2005 involving four Bosch sister companies working in Hungary. In addition to engineering education in the fields of mechatronics for undergraduate, graduate and PhD programs with the utilization of new laboratories like hydraulics, pneumatics, sensor application and development research is carried out. Bosch industry enjoys priority in the selection of the best graduates.
10. There was a complete *reference laboratory* equipped by National Instruments, the world-wide known multinational industry, at the Department of Electrical and Electronic Engineering where relevant research projects, then full-day regular, in-service and other courses can be implemented and run.
11. Specific component of industry-university collaboration in emerging technology is to run 3 to 10 intensive in-service training courses a year on *computer-aided engineering* in various disciplines by academic staff to industry personnel by industry request. Industry technical staff need emerging technology integrating theoretical background of design, operation, diagnostics, condition monitoring, measurement performances, etc. of the respective products, components, devices, equipment, machines, processes, all in one to give responses to adequate challenges by the use of software concerned.
12. 24 to 28 *UM staff serve respective Hungarian Engineering Institutes*, that maintained close co-operation with all important industries in the country, as chairpersons/members of editorial boards of their periodicals, executive-, scientific and professional committees, and invited speakers of their annual conferences strengthen the link directly with these Institutes and indirectly by Hungarian industries, their leaders and specialists as well.
13. *Recognition of talented graduates*: since several diploma theses go to the Engineering Institutes from all Higher Engineering Education Institutions of the country there is an evaluation committee composed of high-ranking industry personnel and principal academics makes decision on the first, second and third ranks of the theses. At the Annual Conferences of the Engineering Institutes usually taking place at end of summer on rotation in different cities of the country the graduates deliver the summary of their theses for 500 to 600 leaders of respective firms and industries. The gold, silver and bronze medals and also the 4th, 5th and 6th ranks are awarded there to the selected outstanding graduates. The summaries of the theses are published in the periodicals concerned like Elektrotechnika (Electrical Engineering), Gép (Machine Industry) or in other periodicals. This event proves to be an excellent forum for the young generation to get acquainted with the respective professional personnel and participate by their works in knowledge transfer and brain circulation.

14. *Short visits* each year are organized for groups of selected UM students to the EU and third countries' industries based on joint agreements between UM and respective Engineering Institutes/Industries with the involvement of 20 to 30 students.
15. Industry contribution to *increase or at least maintain the number of new entrants* to UM by offering attractive technical environment for industrial practice, contributing to the implementation of thesis is highly appreciated. At the opening and closing ceremonies of academic year UM appreciates its industry partners' achievements and awards various University medals to 3 to 5 industry representatives.
16. UM helps industry creating *more jobs for graduates* by publicizing UM-industry link through 30 to 60 projects a year, by conferences, events and written and electronic media.
17. Knowledge generation and transfer are represented well by 8 to 16 *engineering PhD theses* presentations and defenses where industry leaders and specialists, one at each board, are invited as referees, members of evaluation boards, consultants and partly potential employers.
18. *Euro-PhD* will be the future. University of Cassino, Italy runs a European PhD School on Power Electronics in Electrical Machines and Energy Control with mechanical and electrical systems since 2009. The International Scientific Committee with the involvement of one UM academic staff (one of the authors) provides expertise and evaluates the new achievements, contributes to the PhD students' presentation sessions held each year at Spring-time. The PhD students of UM are invited together with other EU and non-EU students to present their scientific achievements for the PhD students' presentation session chaired by the Rector of Cassino and evaluated by the joint professorial-industry group. EU industry leaders, with some Chief Executive Officers, give clear picture on the industries, for the coming research topics and the recruitment chances of PhD-holders. Panel discussions on "Industries meet PhD programs", state-of-the art of research in Europe in this field, future collaboration opportunities, 6 lectures delivered by international experts made the event colorful and useful. Although this program is in its initial stage, paves the way for strengthening the Euro-PhDs.
19. UM organizes each year in Spring-time *microCAD Conferences*. On 31 March and 1 April 2011 the 25th Conference was held by UM. 250 papers were accepted for publication and presentation, UM staff and PhD students received acceptance for 96 papers. The contributions were delivered within 19 scientific sessions; more than 2/3 of sessions were run by engineering departments.

The *result summarized* as UM is (i) possesses sufficient and professional information about industry products, processes, services, infrastructure, management, marketing and technological development trends, (ii) gets familiar with requirements for the new expected graduates, (iii) receives feedback on graduates' knowledge, skill, competences and in indirect way on the quality of teaching, (iv) can improve curriculum, teaching materials and methods, (v) can implement its successful research mission partly by joint projects, (vi) can pave the way for the provision of engineering graduates to the knowledge-driven economy, (vii) reduces the height of the wall between academia and industry what the EC envisaged, (viii) can increase the optimism of Europeans regarding science and technology.

Industry, benefitting of all progress components, (i) can-employ engineering graduates meeting industry requirements, (ii) can get familiar with teaching and research missions of the UM, its infrastructure, (iii) can improve professional quality of joint conferences and events by the active participation of UM academic staff, MSc and PhD students, (iv) can rise science and technology application in new products, processes and services by the invitation/employment of new PhD-degree holders, (v) can generate, and mainly transfer, apply and disseminate new knowledge by joint projects, seminars, in-service training courses and publications worldwide.

All in one UM serves as a *strong research and competence base* both for large international companies and also for SMEs.

REFERENCES

[1] *A Knowledge-intensive future for Europe*. Expert Group Report. European Research Area. European Commission, EUR 24165 EN, p.33. October 2009, Brussels, Belgium.

[2] Borri, C. and Maffioli, F. (eds.): *Re-engineering engineering education in Europe*. p. 190. Firenze, 2007.

[3] Patkó, Gy. and Szentirmai, L., *Improved intellectual capital by mobility as cradle of global engineering*. Proceedings of SEFI Annual Conference, Porto, p. 243-251, 2003.

[4] Patkó, Gy. (ed): *Committed to quality education*, (In Hungarian: Elkötelezetten a minőségi képzésért.) p. 67. Published by University of Miskolc, Hungary, 2008.

[5] Patkó, Gy. and Szentirmai, L.: *How quality correlates to quantity in engineering education of 21st century*. Proceedings of 38th IGIP Symposium. Total volume p.344. Full paper on electronic CD, p.1-18. 6-9 September 2009. Graz, Austria.

[6] Patkó, Gy., Váradi, A. Sz. And Szentirmai, L.: *Sustainable engineering curriculum for the Europe of knowledge.* Proceedings of SEFI (Société Européenne pour la Formation des Ingenieurs) Annual Conference, 27-30 September 2011, Lisbon, Portugal.

[7] *Preparing Europe for a New Renaissance. A strategic view of the European Research Area.* First report of the European Research Area. European Commission, EUR 23905 EN, p.28 Brussels, Belgium, 2009.

[8] Research*eu. the magazine of the European research area. European Commission. Brussels. 2007-2010 issues.

[9] Szentirmai, L. and Radács, L.: *Higher engineering education contribution to a more competitive European industry.* Proceedings of the 7th International Conference on Emerging eLearning Technologies and Applications (ICETA 2009), p.39-48. Printed volume, total p.424, Stara Lesna, High Tatras, Slovakia.

[10] Szentirmai L. and Radács L.: *How to improve competitiveness of European industry by higher engineering education.* Proceedings on electronic Compact Discs of International Conference on Technology, Education and Development (INTED 2010), p. 1008-1021, Valencia, Spain, 2010.

[11] Szentirmai, L. and Radács, L.: *Mutual impact of higher engineering education and a new vision of European Research Area*. Electronic Proceedings of the 8th International Conference on Emerging e-Learning Technologies and Applications (ICETA 2010), p. 1-6, Stara Lesna, the High Tatras, Slovakia.

Tasks, Processes, and Tools: A Design Methodology Management Approach to Design and Development of E-Assessment

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***Abstract*— As technological approaches continue to dominate provision of education in this modern age, effective methods and techniques should be employed in the development of the supporting systems. In this paper we discuss the use of Design Methodology Management (DMM) technology in the development of a formative e-assessment system to support the learning process. DMM promotes a framework type modular approach to system development thereby promoting flexibility and extensibility of the system. Most existing applications of design methodology management, particularly in the electrical design field, have focused on automation of the design process. Our main focus is on the structural representation of the system as well as the flow of data between its components. We first discuss design of the generic e-assessment framework and then describe how we used it in the context of a Data Analysis formative assessment.**

I. INTRODUCTION

A. Definitions

The three distinct key words in *Design Methodology Management* are worth defining first for better comprehension of its meaning.

Design - Reference [1] defines 'design' as firstly, a plan to bring about a man-made product, with that plan aiming to achieve a prescribed goal and satisfy certain constraints; secondly, it is seen as a process of the creative development of such a plan. It can also be defined as a plan for a program to solve a particular problem reflecting the broad structure or architecture of the program. This includes the way it will be broken down into components such as procedures, functions, and data structures as well as an overview of the interrelationships between them. Design creates a representation or model of the system as argued in [2].

Methodology – Methodology is defined as a sequenced set of operations employed in performing a particular function such that, given a methodology, the function can be performed in a predictable and repeatable way [3]. Reference [4] defines design methodology as "the processes, techniques, or approaches employed in the solution of a problem or in doing something: a particular procedure or set of procedures". Reference [5] sees design methodology as sequence of activities required to get from one stage of the design process to another and summarizes it as Design Methodology = Tool set + Design Flow + Constraints. Reference [6] views design methodology as a hybrid design method that uses the techniques of data analysis, structured analysis and top-down design among others. He describes the underlying design methodology system model as consisting of data stores, data flows and processes as well as users. Fig 1 is a representation of this model.

Management - Reference [7] defines methodology management as the functionality of selecting and executing design tools. It is also viewed as the management of a design methodology's component parts, i.e. management of the toolset, the design flow and any required constraints [5]. It addresses the need to manage the manner in which design tools are executed to achieve a desired function.

Design Methodology Management deals with the execution and control of the tools and tasks used in the design process. Reference [8] defines design methodology management as "the selection and execution of an appropriate sequence of tools to produce a design description from available specifications." The main goal of design methodology management is improved productivity on the part of designers making their jobs quick, easy and less error prone. Three attributes of an ideal methodology management system are: 'maintainable', 'parallel', and 'flexible'. If the system is maintainable, adding new tools and supporting new methodologies becomes a straight-forward process. Parallelism relates to the possibility of executing independent tasks at the same time. The system can provide the user with the flexibility of either selecting and executing tools automatically or providing the user with enough information about the tools so that they can manually select as appropriate.

B. Background

Design Methodology Management spawned some

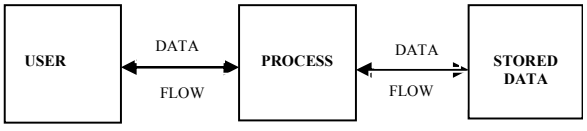

Figure 1. Design Methodology System

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research in the 1980s, but there was even more research activity in the 1990s as evidenced by the various research deliverables in the form of conference and journal papers, and also theses within that decade (e.g. [1], [4], [5], etc.) The origins of DMM are linked to electrical Computer Aided Design (CAD) frameworks. CAD frameworks can be generally described as software environments which provide data management, design flow management, a tool interface, and a user interface. Data management deals with efficient storage (in a database) and retrieval of the design data. Design flow management is about automatic selection and execution of tools used in the design process which promotes rapid production of designs. The tool interface is used for scheduling, integration and execution of tools whereas the user interface is for interaction between the designer and the framework. Examples of CAD frameworks include NELSIS which emphasizes data management, and ULYSSES which focuses on tool management. The following statement sums up the link between CAD frameworks and DMM: "design methodology management systems may be regarded as 'one of the fruits of a good CAD framework'" [4]. An in-depth review of DMM systems as well as concepts is presented in [4].

Design methodology management has been a topic of discussion mainly in the field of Electrical Computer Aided Design (CAD) but it is also applicable to other fields of design like mechanical, manufacturing and software. Different developers and researchers have focused on different aspects of DMM. Some concentrated on design flow management while others were interested in task management, etc. Our work falls under the software design field and the main focus is on modeling of the system using design methodology management concepts to give a clear overview of the system including the flow of data within it.

C. *Design Methodology Management Concepts*

The key concepts which also form the requirements of a design methodology management system are: *tool, process, task,* and also *execution and control.*

A tool is defined as a single executable program capable of performing a specific design function. Tools are required to be described and executed in a manner that is generic and extensible regardless of being automatic or interactive.

A process is a combination of tools and/or other processes that perform a design function. This entails flow of data.

A task is described as an abstraction of a design function. Description of tasks must support sequencing of tools to be executed within the task as well as intra- and inter-task dependency definitions like output and input relations. The descriptions should also include flow control constructs such as conditional branching, selection and iteration, and portability to different design environments.

Execution and control plays the management role of a design methodology management system allowing users to invoke tasks and tools and to monitor their states. The execution environment provides the processing context for tool integration and task flow models. Fig 2 summarizes these descriptions and it forms a basic design methodology management framework on which development of our e-assessment system is based.

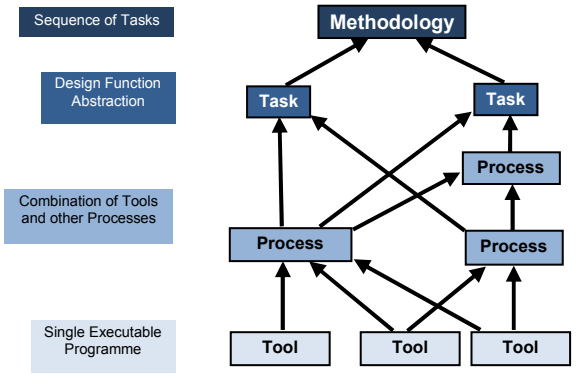

Figure 2. Design Methodology System

II. Overview of E-Assessment Processes

E-assessment is one of the domains of e-learning which involves the use of technology in its provision. Our working definition is given by the Joint Information Systems Committee (JISC) as, "the end-to-end assessment processes where Information and Communication Technology (ICT) is used for the presentation of assessment activity and the recording of responses" [9].

The major benefit of e-assessment systems is their flexibility in terms of global access or anytime, anywhere access. This is made possible by the use of the Internet.

The following is an outline of the general procedures involved in taking an e-assessment.

1. **Access** – The user opens the system by double-clicking on the system icon on their computer desktop or by clicking a web link.
2. **Authentication** – The user logs in, or registers their identification details, for security reasons and also for mapping the feedback to the correct user in a personalized way.
3. **Presentation of assessment activity** – The assessment material is now presented to the user, mainly the questions but also the instructions on the computer screen.
4. **Answering the questions** – The user answers the presented questions which may be all or more than one on a screen or page, or one at a time.
5. **Recording of responses** – The system records all the user's responses or answers to the questions.
6. **Marking the responses** – The system automatically marks the user's responses to the questions.
7. **Presentation of feedback** – The system displays the feedback which can be in form of marks gained or indications of the correct responses, etc, following the marking.

Various other processes, algorithms and settings are undertaken in the background in order to accomplish the above procedure. For example, users' identification details need to be stored somewhere, e.g. a database or a file so that the system can check the entered information at login to see if it matches the stored data. The same applies to the recording of results stage as well as the marking stage. Details of these underlying processes are described in the actual system development. Table 1

TABLE I.
E-ASSESSMENT SYSTEM AND USER RESPONSIBILITIES

Stage	User	System
Access	- Double click system icon, or - Click on web link	- Show interface on computer screen
Authentication	- Register identification details, or - Login	- Record user identification details, or - Check user identification details
Presentation of assessment activity	- Read instructions - Read questions	- Display instructions, and - Display questions on the computer screen
Answering questions	- Give response / answer to question	- Show means to answer the questions, e.g. text entry box
Recording of responses	- Submit given answer	- Store user's response
Marking of responses		- Apply marking algorithms - Allocate mark
Presentation of feedback	- View or read the feedback on the computer screen	- Display feedback on the computer screen – show attained marks; indicate correct answer

shows the responsibilities of the user and the system in following the outlined procedure.

III. MAPPING E-ASSESSMENT PROCESSES TO DESIGN METHODOLOGY MANAGEMENT MODEL

From the definition of e-assessment given in section II of this paper as well as from the information presented in Table 1, we identify the e-assessment tasks to be presented at the top level of the design methodology management model as presented in Fig 2. The top-down design approach is therefore employed to begin with.

Tasks

The main tasks are:

- Presentation of assessment activity
- Recording of responses
- Marking
- Presentation of feedback

The sequencing of these tasks forms an e-assessment design methodology. This can be diagrammatically represented as in Fig 3 showing the view of design methodology as activities to get from one stage of the design process to another. That way the first stage and the last stage (the beginning and the end) can easily be identified. So in our formative e-assessment system case, the first major activity (task) is *presentation of assessment activity* and the last one is *presentation of feedback.* These two tasks form the core purpose-oriented objectives of the system, providing a means for students to engage with learning material.

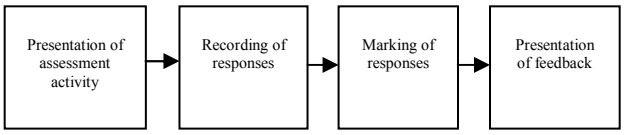

Figure 3. E-Assessment Design Methodology

Another important task which has not been explicitly mentioned before is *Management of user* activity which is applicable at various stages of the design methodology. It includes storage of user identification details needed at the authentication stage, recording of user responses, etc. In Fig 4, the place of this task is shown. Dashed arrows have been used to show the relationships between the main tasks and the implied management of user activity task.

A double-headed arrow has been used between *Presentation of assessment activity* task and the *Management of user activity* task to represent the fact that data related to management of user activity can flow either way from and to these tasks. In the first instance, following Table 1, the user has to either register their identification details or login using the previously registered details. The system manages this process by recording the user's details in a database. If the user enters login details like identification number, the system checks if the user has been registered before and if so, it compares the login details with the information registered about them. Once the authentication stage is passed, the assessment activity is now displayed on the computer screen for the user to tackle. During this presentation of the assessment activity stage, the user may decide to log out of the system at any point. They would be able to do that by clicking a 'logout' button on the computer screen. The system manages that by recording that the user in question has logged out of the system. This accounts for the second arrow head from the *Presentation of assessment activity* task to the *Management of user activity* task.

The arrow from the *Recording of responses* task represents the system's responsibility to store the user's submitted answers to the questions in the assessment activity. The responses are stored in such a way that they are linked to the user's identification details. That way, at the end of the assessment activity, the system will display relevant feedback to each user. The double-headed arrow between *Marking of responses* task and the *Management of user activity* task denotes that firstly, the system requires the user's stored responses in order to mark them. Secondly, following the marking, marks or results are stored in a database to be displayed at the last stage as feedback as depicted by the arrow head from the *Management of user activity* task to the *Presentation of feedback* task. The arrow head at the other end represents the notion that a user may log out of the system after viewing the feedback and, as previously stated, the system will need to record that status.

In DMM terms, the arrows, whether unidirectional or bi-directional represent the *design flow* which effectively is the flow of data.

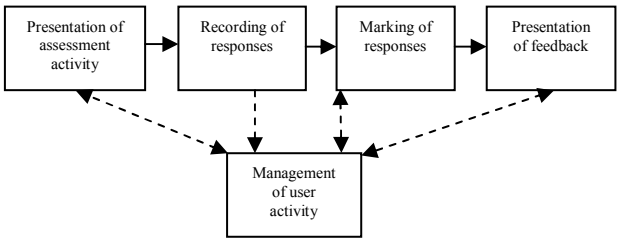

Figure 4. E-Assessment Design Methodology with Management Task

Processes

Below the task level are the underlying processes that are carried out in order to perform the defined tasks which are abstractions of the design functions. Each of the tasks has specific processes that help accomplish it though some processes may be relevant to more than one task especially considering the purpose of the *Management of user activity*.

- *Presentation of assessment activity processes*

The assessment activity is presented by way of displaying it on the computer screen as presented in Table 1. This includes the instructions as well as the questions. So we identify *displaying instructions and questions* as one of the processes needed to achieve this task. This data (instructions and questions) should be stored somewhere to be displayed. As such, *data management* is another process which deals with storage, selection and retrieval of the assessment activity. During presentation of the activity, users should be able to move from one question to the next or back to the previous. This incorporates the *navigation through the assessment* process.

- *Recording of responses processes*

Storing of student answers is the eminent process of the task of recording of responses. Underlying processes include *identifying given answer* which is important for correct recording or storage of the answer. This links with the stage of 'Answering questions' which is sandwiched between the 'Presentation of assessment activity' stage and the 'Recording of responses' stage as presented in Table 1.

- *Marking processes*

Marking processes include *applying marking algorithms* which involve *comparing given answer and correct answer, and allocating marks* per question. The process of applying marking algorithms may be associated with the different question types which include: multiple choice questions (MCQ), true/false questions, gap-filling questions, graph-plotting questions, matching questions and free-text response questions.

- *Presentation of feedback processes*

The main process to achieve presentation of feedback is *displaying score or grade.* For formative assessments though, *displaying correct answer* may be considered the main process as it is required to promote learning. Depending on the purpose and/or requirements of an assessment, the correct answer may be displayed immediately after a student submits an answer. Alternatively, the feedback for all the questions may be displayed at the end of the assessment activity with the given answers displayed alongside for comparison.

- *Management of user activity processes*

One of the main processes of the 'Management of user activity' task is *user account management*. This includes storage of user identification details during registration, and also verification of identification information entered at login. This process is important as it unlocks the system for the user since the assessment activity can only be released when the user has been registered or when their identification information has been confirmed. For assessments which do not need to record student details, this process may be omitted. Due to the centrality of the role played by the 'Management of user activity' task in relation to other tasks as demonstrated in Fig 4, other processes which fall under it are, *storing students answers, comparing given answer and correct answer, selecting correct answer* and *displaying score or grade.*

The generic processes level of the mapped DMM model is shown in Fig 5.

Tools

To complete the DMM framework for e-assessments, we now define the tools required to fulfill the established processes. Considering Fig 5, from left to right, we first define the tools required for the 'Presentation of assessment activity processes'.

- *Tools for Presentation of assessment activity processes*

As previously discussed, for the questions and instructions to be displayed, they should be stored somewhere like a database or a file which needs to be created or set up and managed. This entails such tools as: *create, save, delete, add, update, edit, select, and open.* These tools deal with handling of data. For the process of navigating through the assessment, tools required are for moving forwards and backwards and we define them as, *next* and *previous. Login, logout* or *exit,* are also form of navigation tools. Users may be redirected to other web pages or other applications via links from the displayed assessment activity pages. This requires a *redirect* tool. If a user is automatically presented with the next question after they submit an answer, *submit* can be added to the tools for navigation.

- *Tools for Recording of responses processes*

The recording of responses happens when the students submit their answers. We therefore identify *submit* as the fundamental tool for the process of storing students' responses. Storing the responses to a database or file that is already created means that the responses or answers are added to already existing data so, *add* or *insert* tool is needed. Also, since the students can navigate through the assessment backwards or forwards, they may decide to change their previously recorded answers and this requires an *update* tool.

- *Tools for Marking processes*

Marking processes call for a tool to compare given answer and correct answer. We call the tool *pattern matching.* Allocation of marks is carried out following the execution of the *pattern matching* tool. Therefore, the tool is self-contained to serve the marking processes.

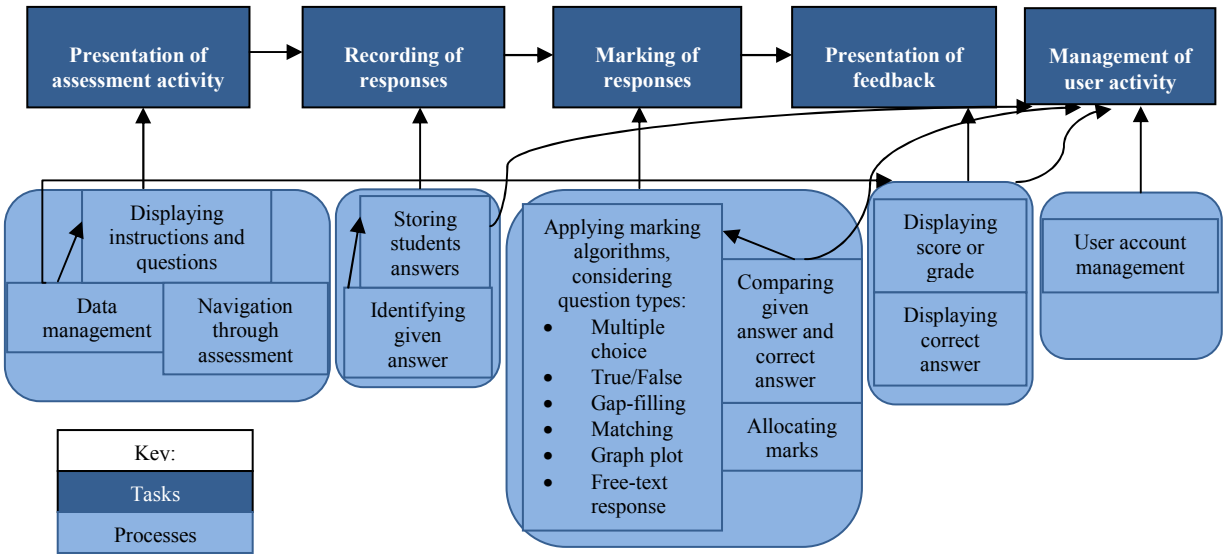

Figure 5. Processes in E-Assessment DMM model

- *Tools for Presentation of feedback processes*

The marks allocated to the student's answers during the marking processes should be calculated before the grade or the score can be displayed. This brings about the *calculate marks* tool. The resulting calculations can be displayed as percentage or as grades. Correct answers need to be selected from the database or file so that they can be displayed, and to achieve that, a *select* tool is defined.

- *Tools for Managing user activity processes*

To manage a user's account, tools needed are: *create account, create password* and *update password.* The involvement of the 'Management of user activity processes' with processes of other tasks which include, storing students answers, comparing given answer and correct answer, selecting correct answer and displaying score or grade, means that some of the tools associated with those processes are also relevant to it. These include, *submit, add, update and select.*

IV. IMPLEMENTATION

A. Requirements of a formative e-assessment system

For the purpose of our study, we used requirements for a formative e-assessment system to support the learning of Data Analysis techniques. A formative assessment gives students an opportunity to engage with learning material and it can be used to help them prepare for summative assessment which is given at the end of a study period normally contributing to their final grade.

The stakeholder, a lecturer of Data Analysis at the University of Derby, required an e-assessment system which could support first year students' learning of data analysis techniques using excel spreadsheet. The lecturer realized how students use manual methods to make various calculations instead of using Microsoft excel's built-in tools to achieve the same results quickly and probably easily.

Nine different variables were given in a table with varying data for 'mean, median, standard deviation, coefficient of variation, skewness measure, range, minimum value, maximum value and number of values'. The students were to use the data to answer questions on the different data analysis aspects by identifying the correct data values from the table and also performing calculations on the data. One of the key requirements was for the data variables to be randomized so as to enable the students to practice on different types of data each time they accessed the assessment. This has implications on the storage of the data.

B. System Architecture

We used the designed e-assessment DMM model as well as the client requirements as guide in the development of the system, starting with its architecture as represented in Fig 6. Central to the system is the database which aids management of the assessment data and the flow of data through the system. The database is storage for the following data segments: questions, answers to questions (for marking purposes), question types, mark value of questions; data variables; students' identification details, including first name, family name and student number; answers given by the students, marks allocated per question per student as well as grades and scores. MySQL database which was already available was used while being hosted by a secure Linux server which also contains the rest of the system files.

The students interact with the system via a web browser on their computers or other devices which connect to the internet. So the other key feature of the system is the *display unit* which can be a computer monitor or a mobile device screen. This is where the registration or login form is displayed for students to fill in order to access the system. As noted in Table 1, students access the system by clicking on a web link to the assessment hosted on the server. The system displays the assessment activity onto the display unit where the students also input their responses to the assessment questions. Once marking is done, the students can also view their feedback on the display unit.

The system files and resources package on the server is a vital component which supports the running of the of the e-assessment system. The files contain definitions of the various tools and processes as well as the flow of data

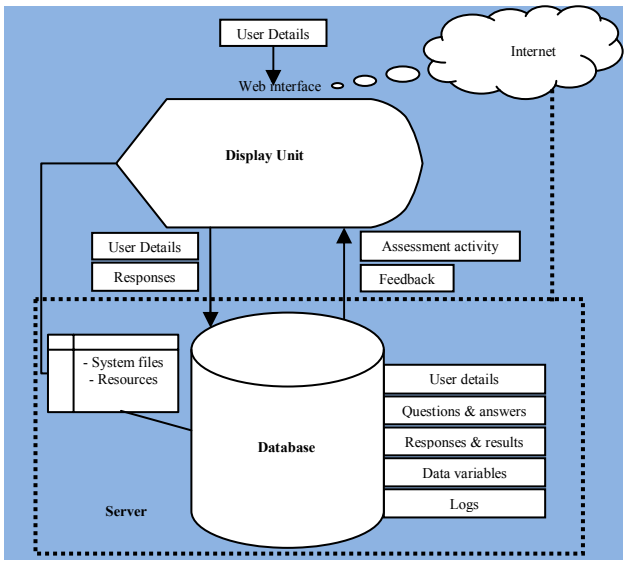

Figure 6. E-assessment System Architecture

as code statements and functions towards fulfillment of the system tasks. The definitions therefore include connections between the display unit and the database where major system activity occurs. Marking algorithms, style sheets and configuration details are also defined in the files. We used PHP scripting language, which suits web application developments, to develop the formative e-assessment system.

C. System Evaluation

Following completion of the development of the system, the Data Analysis students were given the web link to access the assessment. The database was designed in such a way as to track students' activities or interactions with the system. The entries reveal that more than 100 students at least registered their identification details in the system's database. There were about 120 results indicating that students participated in the assessment activity. Out of the 120 results, some are for the same students who engaged with the learning material and practicing answering the data analysis questions using the different data variables which were randomized. This high level of interaction with the system is an indication of students' satisfaction with it. So basically, the system successfully served its purpose. From the few survey results we got, students found the system easy to use and flexible as some accessed it from home while others within the university. Because of the structural flexibility of the system enabled by design methodology management technology, in response to the students and lecturer's feedback, we were able to add more tools for added processes like navigation through the system using 'next' and 'previous' buttons. Text entry marking was found not to be very accurate so it's an area of further research.

V. CONCLUSIONS

In this paper we have defined design methodology management technology identifying the key words that make it up: *design, methodology and management*. While its background shows much activity of application in the electrical computer aided design field, the concepts of design methodology management are applicable to other fields as well. We have demonstrated a different approach to the application of design methodology management as well as to software design. The key concepts of design methodology management, viz: task, process and tool, indeed promote some flexibility in the design of systems. For example, depending on the requirements of an e-assessment system, other tools and processes can be added to the constructed framework in order to tailor it as appropriate.

The structural representation also acts as valuable documentation for the system. That way, another developer could add other entities and extend the system. In our next publication, we aim to present other case studies of adoption of the established Design Methodology Management Framework for E-Assessment Systems to describe the various experiences due to different requirements by the stakeholders.

REFERENCES

[1] H. Zhu, *Software Design Methodology: Principles to Architectural Styles*, Butterworth-Heinemann, 1995.

[2] R. S. Pressman, *Software Engineering, A Practioner's Approach.* McGraw-Hill International Edition, 2005.

[3] K. W. Fiduk, et al., "Design Methodology Management, A CAD Framework Initiative Perspective". Proceedings of the 27th ACM/IEEE conference on Design automation, Orlando, FL, USA. pp. 278 – 283, 1990.

[4] S. Kleinfeldt, S. et al., "Design Methodology Management", Proceedings of the IEEE, Vol. 82, No. 2, February 1994 pp. 231 – 250, 1994.

[5] A. McKnight, Flexible Design Methodology Management, Design Management Environments in CAD, IEE Colloquium, Volume, Issue, 31 Jan 1991 pp. 1/1 -1/6

[6] J. E. Downs, *Basic Systems Design.* Hutchinson Education, 1985.

[7] R. Baldwin and J.M. Chung, "Design Methodology Management using graph grammers", Proceedings of the 31st annual Design Automation conference, 1994 pp 472 – 478.

[8] K. W. Fiduk, et al., "Design Methodology Management, A CAD Framework Initiative Perspective." Proceedings of the 27th ACM/IEEE conference on Design Automation, Orlando, FL, USA, 1990 pp. 278 – 283.

[9] JISC, Effective Practice with e-Assessment; HEFCE, online, http://www.jisc.ac.uk/media/documents/themes/elearning/effpraceffpraceassess.pdf, 6 May 2007.

Performance Comparison of IPsec and TLS Based VPN Technologies

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***Abstract*—IPsec and TLS based VPN technologies are widely used in nowadays networks. But one can hardly find information about their performance, especially compared to each other. So when there was a speed and delay sensitive interconnection project, a direct performance comparison had to be performed. This article realizes a performance comparison of OpenVPN and IPSec based VPN; we measure what throughput each protocol can provide on given hardware while using the same cipher and key length.**

I. INTRODUCTION

The buzzword of this decade in telecommunications is convergence: the convergence of telecommunications, Internet, entertainment, and information technologies for the seamless provisioning of multimedia services across different types of networks. Thus, the future telecommunication network can be envisioned as a group of cooperating heterogeneous fixed and mobile data networks which share a reliable, proven and common Internet Protocol (IP) based backbone. This telecommunication concept based on IP protocol is called IP Multimedia Subsystem (IMS) [1], [2].

The IMS is the unified telecommunication industry approach toward an "All-IP" network architecture that merges the paradigms and technologies of the Internet with the cellular and fixed telecommunication worlds. It aims at creating a reference service delivery platform for provisioning of IP multimedia services in a reliable, secure, and controllable manner. IMS was also adopted as the basis of the Next Generation Networks (NGN) architecture specified by TISPAN [3].

In order to interconnect IMS networks each other and to prevent any security incidents some of VPN (Virtual Private Network) tunneling or encryption should be used. The VPN solutions can be based on e.g. Point-to-Point Tunnelling Protocol (PPTP), IP Security standard (IPsec) or SSL (Secure Sockets Layer) technology [4]. As PPTP solutions are very simple and are also regarded as very insecure, simply because in most implementations there are many not encrypted packets that can be easily spoofed [5] we decided to compare only IPsec and SSL solutions.

Next section contains a brief characterization of SSL and IPsec protocols and their implementations. Section III introduces testbed used for the purpose of comparison and section IV shows results and summarizes coclusions.

II. PROTOCOL BACKGROUND

A. Brief Protocol Description

SSL is cryptographic protocol that provides secure communication over the Internet [6]. The new version of SSL is called TLS (Transport Layer Security) and it is present in all major web browsers. Its security is provided by using cryptography. TLS is a client/server protocol, its connection starts with a TLS handshake covering negotiation between peers for algorithm support, key exchange and authentication and symmetric encryption and data exchange. TLS encapsulates IP in UDP (User Datagram Protocol). IP packets sent from a virtual network adapter are encrypted and encapsulated onto a UDP connection and sent to a remote host over the Internet. The remote host decrypts, authenticates, and de-encapsulates the IP packets using its virtual adapter.

Like TLS, IPsec is also a set of cryptographic protocols that provide secure communication over the Internet [7]. IPsec connection starts with a two phase handshake and when it is completed an arbitrary traffic can be sent via encrypted tunnel. At start a preliminary secure tunnel is created by using of a handshake protocol called an Internet Key Exchange (IKE) [8]. This IKE process authenticates the end points of the tunnel to each other, and securely exchanges the necessary information to create a more permanent tunnel using symmetric encryption. IPsec has two modes: transport mode, which protects only the transported data, and tunnel mode, which also protects the IP header. Client-to-LAN connections typically use the transport mode, while LAN-to-LAN connections typically use tunnel mode.

B. Protocol implementation

IPsec is very flexible and can be used in many ways. IPsec is used to create a majority of the VPN products found today. Checkpoint VPN-1, Cisco PIX, and the open source OpenSWAN are all examples of commonly used VPN solutions that implement IPsec. However, in addition to configuration complexity, IPsec has not strayed interference with kernel space [9]. This principle breaks out the OS into rings of privilege. Ring0 is reserved for the kernel and other essential processes. Ring1 is reserved for other system processes that require low level access to hardware. When moving outward in rings, the privilege of the process is decreased. Ring3 is where most user processes, including TLS implementations, are found. The rules of architecture state that processes in higher numbered rings cannot interfere with processes in lower numbered rings. This provides greatly enhanced stability and security in our applications and allows for multi-user, multithreaded systems. However, IPsec needs low level access to the interface when it modifies IP headers. It operates in ring0.

OpenVPN is open source SSL VPN implementation for Linux and is the major player in SSL VPN field. There are

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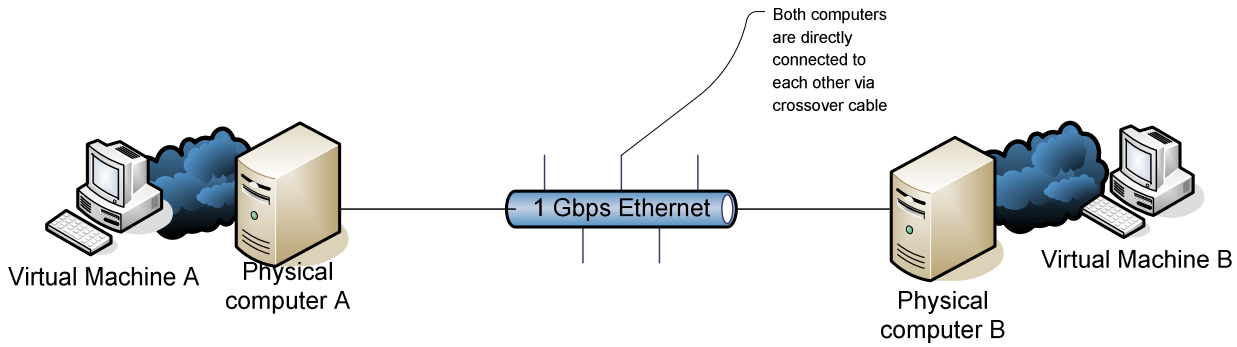

Figure 1. Experimental testbed

other commercial solutions, but none of them are used as widely as OpenVPN and are not always compatible. OpenVPN uses the widespread SSL/TLS protocol to handle tunnel creation and cryptographic elements necessary to create a VPN (the same kind of VPN that IPsec creates) [10]. The main difference is that OpenVPN does not operate as close to kernel as IPsec in user space. OpenVPN does not need to be that close to kernel, because it uses a small "trick". Unlike IPsec, which requires access to the network interface, OpenVPN creates a virtual interface which it can access without kernel dependence and thus it is a little more secure and prone to vulnerabilities by design. The other advantage is that it can be ported more easily to other systems and it runs on Windows, Linux and various Unix versions and Macs.

More computer and VPN users are aware of IPsec than OpenVPN. Therefore we would like to point out that SSL/TLS based VPNs are able to encrypt link traffic in the same way as IPsec VPNs. If looked on the handshake from cryptographical point of view, it uses the same principle of Diffie-Hellman problem as is used by IKE in IPsec. The SSL crypto library is then used to secure the symmetric tunnel, again using similar encryption techniques to those protecting IPsec tunnels [11].

III. Testbed Setup and Performance Parameters

A. Testbed Setup

In order to perform performance comparison for aforementioned technologies we decided to realize real-world network tests between two computers running the Linux Debian operating system (Fig. 1). Usually, in a real world network, there are multiple network nodes (more than two). This, however, is not necessary in our case. We were trying to find out what the computational complexity (and thus throughput) of these two encryption methods was. We also reviewed various network parameters of the implementation of an encrypted tunnel, such as how encryption affects response time.

The performance comparison was made with help of a program called IxChariot. IxChariot is widely used to test network equipment under various traffic patterns. It consists of a console which manages so called endpoints. The endpoints generate (or receive) traffic and report the results to the console [12].

The tests were done using two identical Linux Debian systems running as Virtual machines under the Vmware virtualization program. Windows Vista was used as a host operating system on two physical PCs. Although this does not usually perform very efficiently, it did serve our purpose. The extra computational overhead caused by virtual machine added up and better showed the difference of both algorithms. The tests use IxChariot script with the file size set to 1,000,000 bytes. The tests were performed in both directions – from Virtual Machine A to B and vice versa.

The use of virtual machines in network testing might seem a strange choice at first because they have the disadvantage of additional processing overhead. One can imagine this overhead as a thick layer of software between our network test procedures and the actual hardware. Since there are 2 operating systems in the way, program execution can be almost more complex compared to normal. However, if we look at this fact from another perspective, it outlines the differences between the two technologies we are looking at. As already mentioned, this test is about comparing two similar technologies and if there is a small difference between those two protocols that is difficult to detect, this setup would emphasize them and thus make them better to detect by our network test.

The advantage of using this virtual machines setup was that we could use identical configurations. The second virtual machine (B) was created by a process called cloning. It created an exact replica of the first machine – other than the name and IP address there were no other differences.

B. Performance Parameters

We performed the following IxChariot tests to evaluate next performance parameters:

1. Throughput - Throughput is a measure of how fast data flows through the cable. The test sends data from computer to computer, measures how much time it takes, and calculates the result value in Mbps.
2. Response Time - This test measures all delays that are introduced into a data stream (by link, router), and is essentially what one would measure by using the ping command.

IV. Experimental Results

This section contains test results obtained by using the described test methods. The detailed results are shown only for one direction (computer A to computer B) because of size constraints, however all results (for both directions) will be summarized in table later.

A. Detailed Results - Throughput

First test covered simple scenario with no encryption, no VPN (from computer A to computer B). The throughput behavior can be seen in Fig. 2 where the

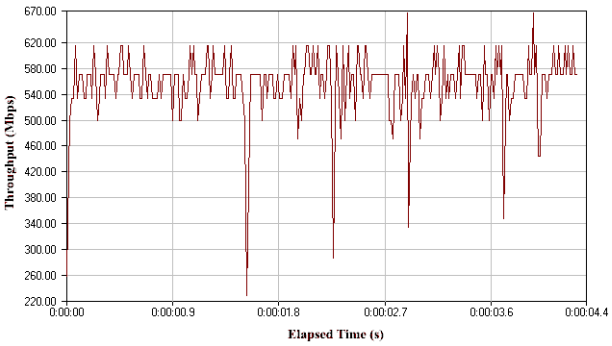

Figure 2. Throughput measured for case with no encryption, A→B

measured average network throughput over the Gigabit network was 553 Mbps. This can be explained by the fact that we did not setup the network to use Jumbo frames. Gigabit Ethernet without the use of Jumbo frames is much lower than its theoretical value.

It is important to mention that the throughput chart shows relatively large variance. It might be due to the nature of Ethernets best effort nature or because of some unknown variables between the physical PC and the virtual machine. However, it is the average value that is important to us. This value can be used as a reference for comparison with the tested setup.

Fig. 3 shows the network throughput when OpenVPN with 3DES cipher was applied. As expected, OpenVPN 3DES exhibits decreased performance. Its average throughput which is approximately 60 Mbps was the lowest recorded for OpenVPN. OpenVPN setup in the test used certificate authority and TLS mode. TLS mode is the most powerful cryptographic mode from a security point of view (and of course that of computational complexity). Comparison with the mode without TLS authentication showed that there was a performance decrease of approximately 5%.

Fig. 4 shows the network throughput when OpenVPN with AES cipher was applied. This test was performed using the same configuration as the previous test, but with a different cipher. We can see that these two ciphers have very similar performance characteristics as for variations. The same can be said of the response time.

The resultant throughput for test with OpenVPN with Blowfish cipher is depicted in Fig. 5. This test was performed using the Blowfish cipher – the default in OpenVPN configuration. We can assume this is going to be a reference configuration for most users. The average value of throughput is around 5.5 times lower than the reference 1 Gbps Ethernet value. The rather large variation in the throughput that we saw in the unencrypted test is here too. We can assume that it is present for the same reasons as in the previous test and is probably not related to OpenVPN. One can say that OpenVPN with Blowfish cipher offers decent throughput at around 96 Mbps.

Most users will probably use the default Blowfish cipher and will not change it to AES, as it does not bring about any notable performance increase or better security. As we have seen, using 3DES is significantly slower and will probably be used only in very specific configurations, or for compatibility reasons.

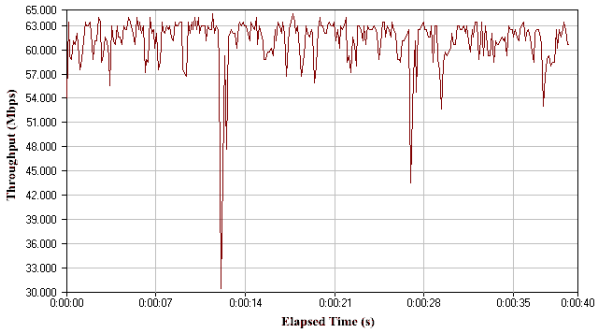

Figure 3. Throughput measured in case with OpenVPN with 3DES cipher, A→B

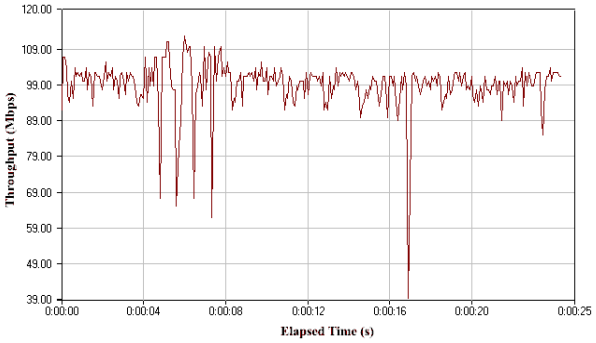

Figure 4. Throughput measured in case with OpenVPN with AES cipher, A→B

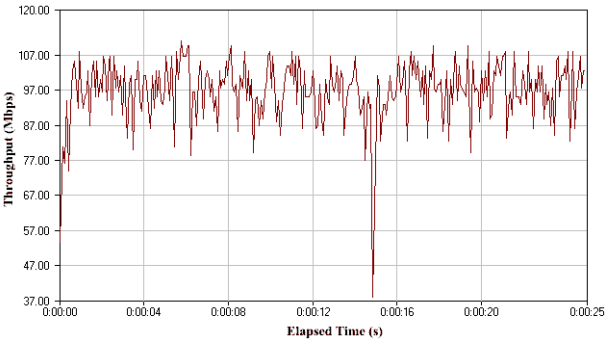

Figure 5. Throughput measured in case with OpenVPN with Blowfish cipher, A→B

Next set of tests was realized with VPN based on IPsec. Fig. 6 and Fig. 7 show charts of the network throughput when 3DES and AES cipher have been utilized. As predicted, IPsec results with AES payload encryption were much better than previous results obtained with default 3DES encryption. AES is clearly superior to 3DES in performance. With the average performance at approximately 140 Mbps, this is a fairly logical result and one that we would have expected. IPsec with its lower level implementation should have algorithms superior to OpenVPN, especially when it comes to speed.

Fig. 8 represents chart of the throughput when Blowfish cipher is applied in IPsec. IPsec with Blowfish cipher showed similar results to those results with AES cipher. The blowfish was unable to overtake AES in throughput, but it shows a lower variance.

B. Overall Results

Now we will summarize and compare consolidated results of all tests performed and say some conclusions

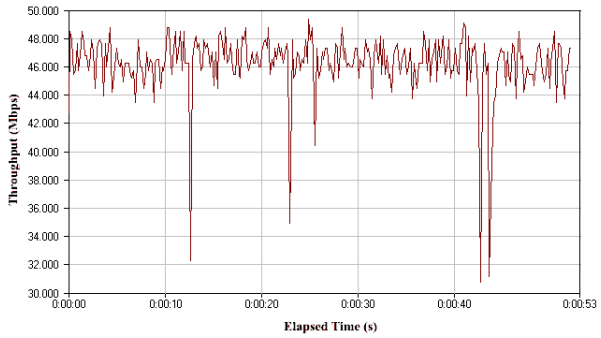

Figure 6. Throughput measured in case with IPsec with 3DES cipher, A→B

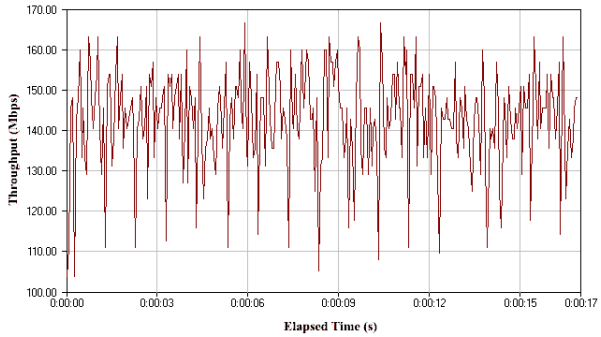

Figure 7. Throughput measured in case with IPsec with AES cipher, A→B

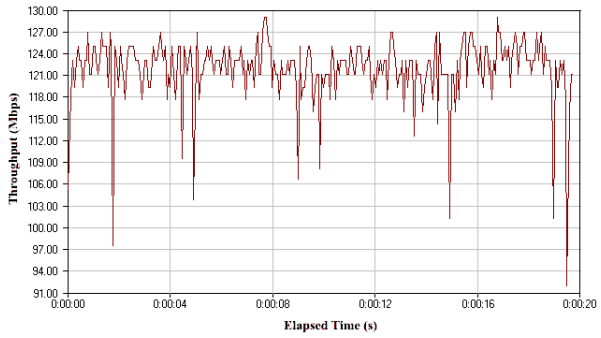

Figure 8. Throughput measured in case with IPsec with Blowfish cipher, A→B

from measured parameters (CPU utilization, throughput, and response time).

The Ixia IxChariot also measured many other link parameters than the one given (e.g. jitter), however there was no significant variation among our tests; therefore these parameters were not further analyzed.

The performance tests we performed show that both OpenVPN and IPsec are capable of creating high performance encrypted links between two or more sites.

As one can see, their performance depends on 3 main factors: the interconnecting link bandwidth, the speed of the encrypting and decrypting device and the type of cipher in use. Our tests show that 3DES is a cipher of the past, and should not be used today. It offers similar (or even less) security to modern ciphers such as AES or Blowfish.

Blowfish and AES offer very similar performance and security. There is no known cryptanalysis and they both can saturate 100 Mbps link on current desktop computers.

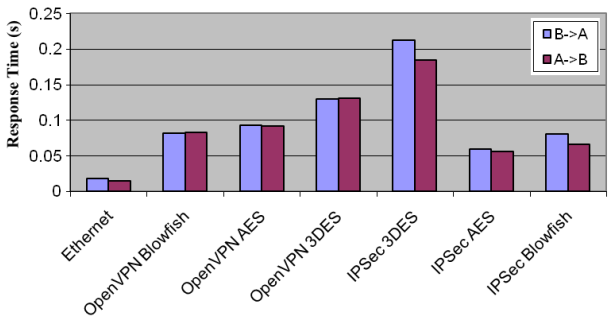

Figure 9. Response time for all realized tests and ciphers for both directions of data transmitting

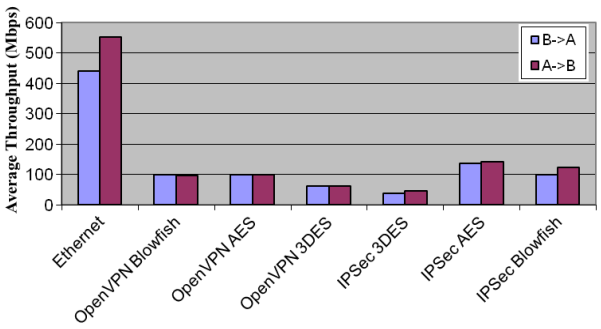

Figure 10. Average throughput for all realized tests and ciphers for both directions of data transmitting

A notable advantage of AES is its standardization and widespread adoption among governments and in the private sector.

Based on Table 1 and Fig. 9 and Fig. 10 we can state that IPsec wins over OpenVPN (while using the same type of cipher) by a rather small margin. It is faster while using AES and Blowfish ciphers and also has smaller delay. It loses only when 3DES cipher is used, but this is not that significant, since this obsolete cipher probably won't be used anymore.

However OpenVPN, and other SSL based solutions, have some strong points too. Most notably, it is ease of use and flexibility. Configuring and installing OpenVPN is a child's play compared to IPsec. Let us take the documentation as an example. IPsec documentation is spread over 6 or more different manual pages, which makes it quite difficult to use. OpenVPN has one documentation file and one "How-to", both of them are on OpenVPN website and also in Linux manual pages. Another area where OpenVPN wins in our opinion is complexity. This point has already been mentioned in this paper, when describing community reactions to the IPsec. We can therefore ascertain that this is true.

V. Conclusion

This paper concentrated on VPN technologies which utilize SSL/TLS or IPsec protocols to create secure tunnel for data transmission, e.g. to interconnect two IMS networks. A several tests have been performed to compare these technologies based on parameters such as throughput, response time and so on. We can summarize that it is difficult to choose the better of these two technologies based on all views. Each user has different needs. For our implementation we decided to choose OpenVPN, due to its simplicity and fast and straightforward implementation. On the other hand IPsec

TABLE I.
TYPE SIZES FOR CAMERA-READY PAPERS

Test	Response average (s)	Response maximum (s)	Average throughput (Mbps)	CPU utilization sending node	CPU utilization receiving node
A->B Ethernet	0,014	0,035	553	71	81
B->A Ethernet	0,018	0,038	440	90	59
A->B OpenVPN Blowfish	0,083	0,2	96	66	90
B->A OpenVPN Blowfish	0,081	0,3	99	95	77
A->B OpenVPN AES	0,092	0,19	98	62	94
B->A OpenVPN AES	0,093	0,3	99	93	78
A->B OpenVPN 3DES	0,131	0,263	60,98	78	94
B->A OpenVPN 3DES	0,129	0,352	61,77	92	86
A->B IPsec 3DES	0,184	0,28	45	99	40
B->A IPsec 3DES	0,212	0,37	37,7	99	32
A->B IPsec AES	0.056	0.077	142	90	84
B->A IPsec AES	0.059	0.1	135	97	63
A->B IPsec Blowfish	0,066	0,087	121,76	98	73
B->A IPsec Blowfish	0,08	0,197	99,87	99	52

is somewhat faster and as it has been on the market much longer than SSL VPN solutions and it has far more support among hardware and software vendors.

ACKNOWLEDGMENT

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REFERENCES

[1] 3GPP, *Service requirements for the Internet Protocol (IP) multimedia core network subsystem (IMS); Stage 1*, 3GPP TS 22.228, 2011, http://www.3gpp.org/article/ims.

[2] 3GPP, *IP Multimedia Subsystem (IMS); Stage 2*, 3GPP TS 23.228, 2011, http://www.3gpp.org/article/ims.

[3] C. Esteve Rothenberg, *Fixed-mobile Convergence in TISPAN/3GPP IMS: Conception and Evaluation of Systems for Seamless Vertical Handover*, VDM Verlag, 2008.

[4] M. Lewis, *Comparing, Designing, and Deploying VPNs*, Cisco Press, 2006, 1080 p.

[5] B. Schneier and Mudge, "Cryptanalysis of Microsoft's Point-to-Point Tunneling Protocol (PPTP)," Proceedings of the 5th ACM Conference on Communications and Computer Security, ACM Press, pp. 132-141.

[6] T. Dierks and E. Rescorla, "The Transport Layer Security (TLS) Protocol Version 1.2", IETF RFC 5246, 2008, http://tools.ietf.org/html/rfc5246.

[7] S. Kent and K. Seo, "Security Architecture for the Internet Protocol", IETF RFC 4301, 2005, http://tools.ietf.org/html/rfc4301.

[8] D. Harkins and D. Carrel, "The Internet Key Exchange (IKE)", IETF RFC 2409, 1998, http://tools.ietf.org/html/rfc2409.

[9] B. Schneier and N. Fergusson, "A crypthographis evaluation of IPsec", 2003, http://www.schneier.com/paper-ipsec.pdf.

[10] M. Feilner, *OpenVPN: Building and Integrating Virtual Private Networks*, PACKT, 2006, 258 p.

[11] CH. Hossner, "OpenVPN and the SSL VPN Revolution", paper from SANS Institute, 2004.

[12] Ixia, "IPsec Virtual Private Networks: Conformance and Performance Testing - Sample Test Plans", 2004, http://www.syrus.ru/files/pdf/ixia/ipsec.pdf.

Digital Literacy in Slovakia 2011

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Institute for Public Affairs (IPA), with the support of Accenture – Pontis Foundation, Cisco Slovakia, Hewlett-Packard Slovakia, Microsoft Slovakia and the Slovak Telekom Foundation Fund, has carried out the fourth year of the *Digital Literacy in Slovakia* survey. Findings from the representative sociologic survey offer answers to questions to answers regarding the ratio of digital literacy and illiteracy within the Slovak population; population's experience with the info-communication technologies (ICT); level of their digital skills, and adaptation to the ICT.

I. Share Of Digitally Literate Slovak Population

Being one of the key indicators of the development in the are of society's informatisation, digital literacy of the Slovak population is relatively positive when compared to international standards. According to research results by Eurostat, from 2005 to 2009, digital skills of Slovaks were slightly above the European level (EU 25).

As shown in Figure 1, the proportion of the digitally literate people ranged from 65 % to 71%, with the EU

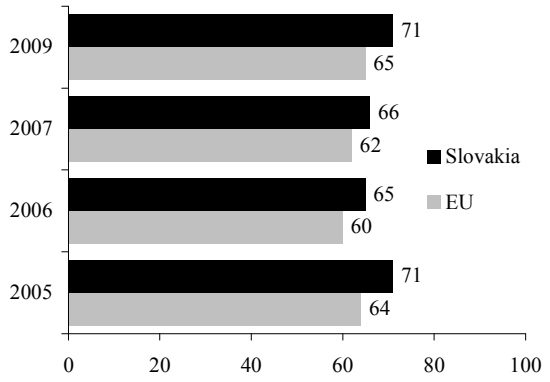

Figure 1. Share of digitally literate population in Slovakia and EU average (in %)

average for the individual monitored periods reached 62 % to 65 % at the most. For example, in 2009 Slovakia outperformed Belgium, Bulgaria, Czech Republic, Estonia, Ireland, Greece, Spain, Italy, Latvia, Lithuania, Cyprus, Hungary, Malta, Poland, Portugal and Romania [5].

The latest results of a survey conducted by Institute for Public Affairs on group of 1138 respondents over the age of 14 showed the share of the digitally literate population in Slovakia has again increased (see Figure 2). The share of the digitally literate and the digitally illiterate is 76 % : 24 % [4].

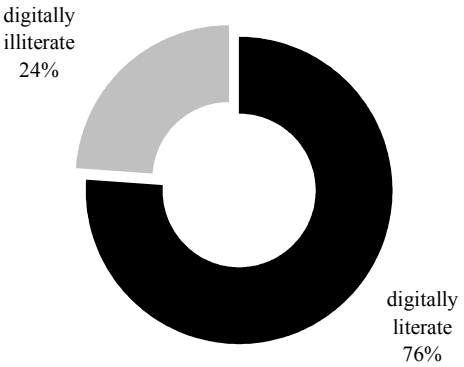

Figure 2. Share of digitally literate and digitally illiterate population in Slovakia – 2011

The largest segment of the population has 'common' skills, such as working with a PC (including laptops, tablets and smartphones), sending text and multimedia messages (SMS and MMS), e-mailing, working with a text processor, Internet browser, searching for information and registering access to various online services, or printing out documents. These skills are declared by 64 % to 72 % respondents.

On the other hand, a far smaller portion of the respondents are able to work with more sophisticated technologies. For example, working with databases, working with a network (searching, transferring or copying data on a LAN), working with a graphic editor, online banking, or installing applications and setting up PC functions are tasks that can be handled by only half of the respondents. However, the fact that a proportion of the population is skilled with ICT does not necessarily mean the users are also able to use ICT without any problems. Such usage is, as will be demonstrated by further details about the level of digital literacy, indeed quite differentiated.

II. The Level Of Digital Literacy

On one hand, the share of the digitally literate and the digitally illiterate demonstrates the skills and capabilities within the population in general, i.e. whether the population is or is not experienced in working with ICT. On the other hand, this ratio does not say anything about the level (quality) of these skills – in other words, who 'good' or 'bad' the population is at using ICT. For the purposes of assessing such skills and capabilities, the Digital Literacy Index (DLI) is used. It takes into account 28 indicators – answers to questions that were asked the respondents in order to determine the level of their experience in working with ICT, its applications and services. The index provides values on a scale from 0 = digital illiteracy, to 1 = maximum level of digital literacy.

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As shown in Figure 3, the overall level of the population's digital literacy did not change over the last two years. While the DLI value continually increased from 2005 to 2009, rising from 0.33 to 0.44 points, in 2011 it remained roughly on the same level as two years before – on 0.43 points. In other words, Slovakia's population aged 14 and above would score 43 out of the total possible 100 points for its digital literacy.

For better illustration: if there were three levels of digital literacy – Low, Medium, and High[1] – then from 2005 to 2011 Slovakia gradually 'worked its way' from Low to Medium level.

There might me various reasons why the relatively optimistic trend from the period of 2005 to 2009 had stopped. One of the hypotheses, supported also by the data on penetration and the use of personal computers and the Internet in Slovakia, could be a certain 'saturation' of ICT within the population. In other words, those who wanted or needed to found their way of accessing ICT, while at the same time gaining necessary skills for working with ICT. Another reason might be a subjective satisfaction with the achieved digital capabilities, a certain level beyond which there is no reason to go.

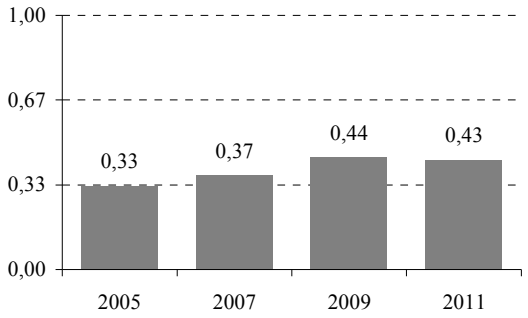

Figure 3. The level of digital literacy in Slovakia 2005-2011 (DLI – Digital Literacy Index)

Along with inner motivation, an important role is also being played by the ability to learn and adapt. For example, over the course of 6 years, the proportion of people who have problems with adapting to ICT practically did not change at all. As shown in Figure 4, this group still consists of one fifth of the population. Another 28% of those who refuse to adapt to ICT need to be added, too. It is this group of people who represent the greatest 'brake' on development.

III. Which Areas Improved And Which Worsened?

Assessment of specific digital skills shows that in comparison with 2009, the population's ability to work with hardware and software practically did not change [3]. The only exception is an improvement in working with mobile devices such as laptops, tablets or smartphones. This can be linked to the growing interest in mobile devices. For example, according to the latest data from mobile operators, every second mobile phone is a smartphone. A very slight improvement occurred in the population's capability to work with information and services within the Internet's virtual environment, such as searching for information and registering for services, using Internetbanking, online shopping for products and services, downloading/uploading data, etc.

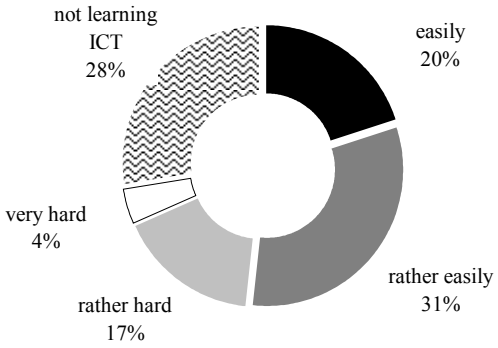

Figure 4. The willingness to adjust to/learn ICT in Slovak population

On the other hand, deterioration was most noticeable in the area of communication via text or multimedia messages. It is probable this development is due to the already mentioned penetration of smartphones, which some part of users is only starting to be 'acquainted' with. However, social network skills were at a relatively positive level.

In 2011, majority of the assessed digital capabilities reached a medium level. Respondents have greatest problems with 'working on a network' (e.g. moving or copying data within a LAN, searching for various types of information, etc.), also with using databases and graphic applications, installing software and hardware, and setting up basic PC functions.

IV. How Different Social Groups Adapt To And Learn Working With ICT?

The statistical analysis confirmed a strong link between the level of digital literacy and the adaptability.[2] In general, people who learn and adapt easier reach a much higher level of digital literacy, and vice-versa. 20 % of the population claiming they learn and adapt smoothly can be considered as having no problems in this area. Their digital literacy is high above the average level – 0.86 points. Another 32 % of respondents think they mastered ICT with small problems, but their skills are still above the national average (0.65 points). On the other hand, 17 % of respondents claim they learn 'with some difficulties', and reach only a very low level of digital literacy (0.27 points). Although another part of the population is small in volume (4 %), its members have great problems with using ICT – they adapt with considerable difficulties and their level of digital literacy reaches only 0.11 points. The remaining 27 % of the population completely ignores the process of learning new digital skills.

[1] Low level < 0.33 points; Medium level = 0.34 to 0.66 points; High Level > 0.67 points.

[2] The Kendall's tau_b correlation coefficient reaches the level of 0.807 points. From a statistical point of view, this demonstrates a very high degree of dependency.

Adapting to ICT is closely linked especially to age, education, social status and type of the household, and the related economic activity. For example, while as many as 90 % of those from the group aged 14 to 17 adapt easy, only 6 % from the group aged 60 and above adapt without problems. In a similar fashion, the population's ability to adapt drops dramatically with decreasing level of education. While among those university-educated 83 % adapt easily, only 34 % claim the same from the group with basic level of education. Significant differences occur also depending on the type and social status of the household. E.g. households of younger people and those with higher financial status adapt much better than those of older people and with poorer financial status.

Just like on the nation-wide level, the close relation between the ability to adapt and the level of digital literacy was found also on the level of various social-demographic groups. In other words, the higher the ability to learn and adapt within a given group (i.e. with less problems), the better its digital skills. Naturally, the ability and willingness to adapt is only one of the factors influencing digital literacy growth. Results already from previous years showed there are quite exogenous factors, such as work or school. [1].

With respect to the further development of digital literacy, the survey results also make it possible to identify certain risk groups, i.e. groups of people, who are very likely to have great difficulties with adapting digital skills (just like they did until now), or who will completely abandon any attempts at improving. In some groups, the share of those 'adapting with great difficulties' and those who 'do not adapt at all' is high above the average. This includes namely people above the age of 55 (more than 76 % of them), people with only basic level of education (66 %), the unemployed (62 %), pensioners (95 %), financially weak or poor households (72 %) or households of old people (96 %). In this aspect, population's adaptability is an important factor parameter, which contributes towards the so-called digital gap within a society.

V. Digital Divide in Slovakia

Several years of mapping the issue of digital literacy revealed an troublesome fact: that the society started to divide into the group of those who have access to ICT, and thus have the relevant level of digital literacy, and the group of those without such access and skills. As was confirmed by the results of this survey, the development

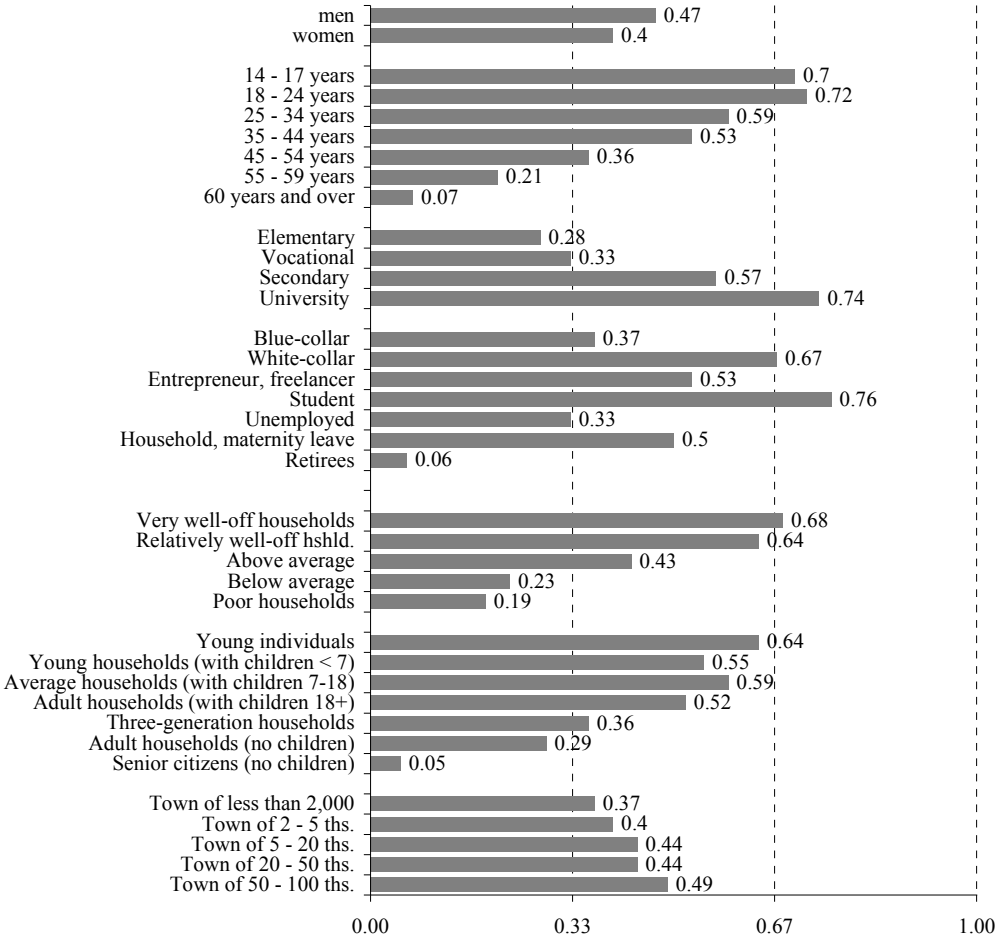

Figure 5. The level of digital literacy in social groups (DLI – Digital Literacy Index)

in 2011 has the same trend. During the last 6 years, Slovakia acquired characteristics of a digitally divided society. On one side, there are social groups that can be identified as being 'progressive' – is younger, more educated, better qualified, socially stronger and located more in urban areas. On the other side, there is the older, less educated economically inactive part of the population with lower qualification (pensioners, the unemployed). While the former continues to learn and improve, the latter is so-to-say stuck in one place, not being able to adapt. However, the last monitored period (2009 – 2011) is specific in that improvement was not achieved even in the 'progressive' groups of the population.

Nevertheless, just like in the past, in 2011 the group of the digitally most literate people includes those aged 14 to 24, with university, college or A-levels education, those working mentally and students, people employed in the public sector, financially strong households, households of the young people, and respondents from large cities with over 100,000 inhabitants.

On the other hand, long-term low level of digital literacy (or even digital illiteracy) is typical for people over the age of 55 (for the group of those aged 60 and above, this reaches the level of digital illiteracy), also for people with only basic and higher education without A-levels, the manual workers, pensioners, the unemployed, households of the old people, households with low level of income, and respondents from small cities (up to 2,000 inhabitants).

One of the reasons for this situation is also the state's long-term ambivalent attitude towards the issue of human resources and improving the population's digital literacy. When we summarise the related projects from the recent years, we can say the state focuses predominantly on supporting digital skills within the official education system. In other words, it provides for acquiring digital literacy by the youngest part of the population – students of basic schools and higher education institutions (including teachers). Therefore, the issue of improving the digital literacy of those who were not able to develop related skills in school, is addressed by the private sector in cooperation with NGOs and schools.

REFERENCES

[1] *Digital literacy in Slovakia 2005*. Empirical Data from an IVO Sociological Survey. Bratislava: Institute for Public Affairs, 2005

[2] *Digital literacy in Slovakia 2007*. Empirical Data from an IVO Sociological Survey. Bratislava: Institute for Public Affairs, 2007

[3] *Digital literacy in Slovakia 2009*. Empirical Data from an IVO Sociological Survey. Bratislava: Institute for Public Affairs, 2009

[4] *Digital literacy in Slovakia 2011*. Empirical Data from an IVO Sociological Survey. Bratislava: Institute for Public Affairs, 2011

[5] *Individuals' level of computer skills*. Eurostat metadata. [Online] [cit. 9/21/2011] http://epp.eurostat.ec.europa.eu

Draft of Standards and Specifications for E-Learning in the Section of Ministry of Education, Science, Research and Sport of the Slovak Republic and in the Operational Programme of Education funded by ESF

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Abstract - **This paper presents the draft of Standards and Specifications for E-Learning in the Section of Ministry of Education, Science, Research and Sport of the Slovak Republic and in the Operational Programme of Education funded by ESF.**

I. INTRODUCTION

Draft of standards and specifications for electronic learning (e-Learning) is a result of an initiative working group composed of academic and business representatives and established under the authority of the Minister of Education of the Slovak Republic, Mr. Ing. Eugen Jurzyca.

The initiative of the group is based on the knowledge of a feasibility study "Digital Content of the National Programme of Education" (DONPVV), which, along with other documents relating to DONPVV, do not define standards and specifications for e-Learning and as such, it may lead to further encouragement of the current situation, that is, creation of incompatible e-Learning systems causing possible operational problems and economic losses in the section of the Ministry of Education.

II. VISION

To build e-Learning systems in the Section of the Ministry of Education and outside it within the framework of ESF – the Operational Programme of Education – on the basis of a united standard so that it is possible to create, share and link objects with the educational content in the open environment of educational content creators and suppliers of learning management system (LMS, LCMS – Learning Content Management Systems) and thus exploit the synergy between teachers, national and international suppliers of the content, and providers of e-Learning systems.

III. OBJECTIVES

To approve standards and specifications for e-Learning in the section of the Ministry of Education and other sections that implement e-Learning within the framework of the ESF programme - OP of Education - in which the Ministry serves as the managing authority. To approve these standards and specifications also for the activities funded by current and capital resources of the state budget and other financial resources within the framework of the Ministry of Education and within other areas of social and economic life in which the Ministry serves as legislative and normative state authority (system of formal education, system of informal education, linking the science and research to education, sport and to economic practise, etc.). To recommend the use of these standards and specifications in other sections.

The standards must:

- Be opened, technologically independent and stable in terms of future development of IT infrastructure
- Be adaptable to different requirements of educational institutions (primary schools, secondary schools, lifelong learning, etc.)
- Ensure interoperability of different objects of educational content with different LMS (Learning Management Systems)
- Ensure reusability in different contexts and different applications
- Ensure availability of e-Learning objects in accordance with the intentions of DONPVV, that is, e-Learning system must be provided as a web service.

Application of the standards should include:

- Raising an adequate level of information and awareness in professional and general public in relation to the benefits of standardization; providing free tools for sectors, which will help with standardization (if a teacher decides to use a software tool for creation and publishing of e-Learning content from the day of the adoption of the standard and in accordance with it, and the tool is not available, he shall be granted obtaining the tool in a short period of time and without the necessary current and capital investments of his institution)

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- Development and adoption of legal and procedural rules governing the course and score of the process, organization and documentation of e-Learning in relation to the various systems of education (formal education, informal education).

IV. Recommended Standards for e-Learning

The working group have considered a number of e-Learning standards and it pronounce the SCORM (Sharable Content Object Reference Model) standards drafted within the framework of ADL (Advanced Distributed Learning Initiative) by the Office of the United States Secretary of Defence in 1997, to best meet the objectives of e-Learning as defined in Art. 3 and objectives defined in the feasibility study DONPVV.

SCORM is a referential model harmonizing partial standards of a number of standardizing bodies:

- Alliance of Remote Instructional Authoring and Distribution Network for Europe (ARIADNE)
- Aviation Industry CBT Committee (AICC)
- IEEE Learning Technology Standards Committee (LTSC)
- IMS Global Learning Consortium, Inc.

SCORM is a world wide spread standard for e-Learning. Using SCORM standard in e-Learning content development has proven to save from 50 to 80%.

A. SCORM

SCORM defines SCO (Sharable Content Object) as a basic element of educational content which enables sharing and reuse of the content in a different context and in different e-Learning courses according to the needs of users. SCO may contain various forms of information – text, image, photo, and video. Each SCO contains metadata enabling the search and sharing of SCO by various LMS (Learning Management System) systems conforming to SCORM.

SCORM is focused on the Interface between educational content and LMS; but it does not address specific features and capabilities of LMS.

SCORM CAM (Content Aggregation Model) defines the way of elementary SCO grouping into more complex units; how to store, locate and manage a single SCO.

SCORM Content Package groups SCO or their aggregations into units representing a specific course, lecture or learning module.

SCORM RTE (Run-time and Environment) describes the requirements for LMS ensuring the interoperability of SCO and various LMS systems. These are the defined processes of location and delivery of educational content to learner, the way of communication of SCO with LMS using API (Application Program Interface) and a defined data model for data exchange between SCO and LMS during the implementation of educational process.

SCORM SN (Sequencing and Navigation) defines a method of achieving desirable behaviour of learner so that each LMS gradually sequences the learning activities according to the planned "activity tree" which allows individual access to each learner based on his ability to absorb the educational content.

SCORM defines what must be tested to ensure the conformity of educational content and LMS systems and it provides user tool for LMS, SCO and Content Package testing. In addition to testing of SCORM conformity with provider´s own capacity or creator´s e-Learning system, ADL also provides certification of e-Learning in their laboratories.

B. SCORM Development

In its development, SCORM has reached a number of generally recognized versions:

- SCORM 1.2., 2001.
  It is still the most commercially used version but it does not offer sequencing. ADL does not work on its development anymore.
- SCORM 2004, 2nd Edition, 2004.
  It enhances original features of version 1.2., integrates IEEE and IMS results and implements sequencing.
- SCORM 2004, 3rd Edition, 2006.
  This version has improved definitions of the 2nd Edition with regard to the development of IEEE and IMS standards. It is spread comparably to SCORM 1.2.
- SCORM 2004, 4th Edition, 2009.
  The version continues to develop SCORM 2004, but it has not been significantly spread, yet.
  All SCORM 2004 versions are compatible bottom-up. E-Learning products created on the basis of SCORM 1.2., can be upgraded to SCORM 2004 using relatively simple conversion ADL tools.

C. Methodology of SCORM Standards and Specifications Implementation

The working group recommends that the Ministry of Education, Science, Research and Sport of the Slovak Republic declared SCORM 2004 a mandatory standard for all newly-procured e-Learning systems and for the purchased and created educational content for these systems within the framework of the Ministry of Education and The Operational Programme of Education in which the Ministry of Education serves as the Managing Authority. It is recommended that the Ministry of Education confirms SCORM 1.2. as a temporary standard which is going to be used for the period of 3 years in previously implemented e-Learning systems based on this standard (e.g.: Planet of the Knowledge). After the 3-year period, the systems based on SCORM 1.2. should be converted to conform SCORM 2004. Moreover, it is recommended that the standard is adopted for all newly-procured e-Learning systems and for the

purchased and created educational content for these systems financed by resources other than OP of Education within the framework of the Education section and subjects belonging under the legislative body of the Ministry of Education within the framework of the system of formal and informal education, linking the science and research to educational systems and linking education to economic practise and systems of sport education.

All SCO and LMS can be used in the section of the Ministry of Education until after the test of compliance with SCORM 2004. The test will be provided by an entrusted departmental organization. It is recommended to grant a time-limited exception of this rule in cases specified in Art. 4.4.

D. Use of Existing Educational Content

The working group is aware of the presence and extend of the existing educational content, which has been long formed by various authors and is currently available from various resources. The content is valuable in many cases and it is used in practise but its universal applicability is limited due to the absence of a unified creational standard. After the standard is adopted, the content should be revised and preserved.

Help can be provided in several forms:

- Creating software tools for conversion,
- Conversion assistance,
- Creating own LMS and LCMS compliant with SCORM 2004, which will be able to work simultaneously with several standards,

The working group recommends this educational content to be converted into SCORM 2004 standard within the period of 3 years after introduction of the standard. For financing, it is recommended to consider the use of ESF and ERDF funds designated to finance projects on informatization of schools, development of e-Learning content and also for support of e-Learning content transformation to the recommended standard.

V. OPERATING THE E-LEARNING.SYSTEMS

The working group sees very different abilities of particular schools to ensure operation of e-Learning systems; therefore it clearly supports a system with centrally managed repository of approved curriculum which will be available in real time and accessible for all educational institutions in Data centre of the Ministry of Education.

Once approved educational content and other pedagogical aspects by an organization authorized by the Ministry of Education, Data centre of the Ministry of Education should be authorized to provide tests of conformity with the new content in the form of SCO with SCORM 2004 standard as well as approval of LMS and LCMS systems based on the tests of conformity with the standard and compliance check with procedural operational standards of Data centre of the Ministry of Education. Educational organizations should be allowed to use only LMS and LCMS systems in e-Learning approved by the body authorized by the Ministry of Education on the test basis of conformity with the standards.

VI. E-LEARNING AND FUTURE PROJECTS OF OP OF EDUCATION CALLS FOR 2011 – 2013

The working group recommends the following steps to ensure e-Learning systems to be based on the approved standards:

- Purchase of finished educational content with LMS and LCMS delivered as a part of purchased educational content (it is a condition that they are based on the proposed standard and thus are independent of the original software platform).
- The licence model will be applied in order to meet the ESF price constraints for single person module or class module.
- To provide a complex education, in addition to purchasing the educational content in electronic form it is appropriate:
- To provide simultaneously the training for using of the content in the form of full-time education (service).
- To provide simultaneously printed textbooks to compliment the educational content because it is crucial for learners to revise their knowledge even when they are not online. Acquisition of textbooks as educational aids supports the effect of e-Learning and so it is necessary to link the books with the provided educational product. The reason is that the ESF funds are not designated for purchase of common textbook collections – these should be purchased from current budget, and so it is highly probable that ESF would identify such purchase as a violation of additionally and overlapping of expenditures due to which the resources should be returned. It is therefore appropriate to systematically prevent the purchase of common textbooks on the level of calls by indicating in the call that the resource is not designated for purchase of textbooks used in national curriculum as stated in editorial plans or in school educational programme at involved schools (as these are commonly used textbooks commonly available on the market and they are not modern educational aids nor they comprise modern educational content and so the EFS resources are not designated for their purchase.

VII. CONCLUSION

The current state is defined by the presence of a great number of educational systems and educational content of different quality that is deployed only locally with no possibility to be shared among the schools and educational institutions. Moreover, the central administration is not possible, which prevents obtaining an overview of the extent of its use and quality. The lack

of measurable indicators makes it impossible to set requirements for newly purchased content and to focus on its further improvement. Ultimately, the section of Education loses the opportunity to control and make use of innovative methods of education and improve the quality of education.

The introduction of standardization of e-Learning educational content affects several levels. The fastest benefit will be the procurement cost reduction. Formulation of content standardization requirement will open the competition for Slovak and foreign suppliers and will allow the use of market mechanisms to control the price.

Taking the long term view, SCORM will rapidly reduce operating costs, as it enables reusability of educational content elements (SCO) in creation of new classes. At the same time, a multiple use of SCO will be possible due to their inclusion into multiple modules, classes or subjects.

As the e-Learning systems will be based on an internationally used standard, platforms and suppliers will be no more limited; the base of suppliers will be extended and opportunities of creative involvement of teachers and schools will be increased. Automated tools for creating and conversion of content into SCORM format will allow the teachers to create new educational content. Thus, it will be possible to obtain the feedback of needs of learners and educators. Engaging university students with educational focus may lead to better understanding of the needs and processes of e-Learning.

The central provision of the standardized educational content will, at the same time, enable the monitoring the extensive use of the content and evaluation of its quality from the perspective of learners and educators in the real-time. It will provide feedback for specialized departmental organizations such as National Institute for Education, UIPŠ, ŠIOV, etc. on real operation of e-Learning. Thus, the Ministry of Education will obtain a powerful tool for management and modernization of the Slovak educational system.