RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2011 Number 30

FIVE YEARS OF RESEARCH INTO TECHNOLOGY-ENHANCED LEARNING AT THE FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY

Štefan SVETSKÝ, Oliver MORAVČÍK, Dagmar RUSKOVÁ, Karol BALOG, Peter SAKÁL, Pavol TANUŠKA

Abstract

The article describes a five-year period of Technology Enhanced Learning (TEL) implementation at the Faculty of Materials Science and Technology (MTF) in Trnava. It is a part of the challenges put forward by the 7th Framework Programme (ICT research in FP7) focused on "how information and communication technologies can be used to support learning and teaching". The empirical research during the years 2006-2008 was focused on technology–driven support of teaching, i. e. the development of VLE (Virtual Learning Environment) and the development of database applications such as instruments developed simultaneously with the information support of the project, and tested and applied directly in the teaching of bachelor students.

During this period, the MTF also participated in the administration of the FP7 KEPLER project proposal in the international consortium of 20 participants. In the following period of 2009-2010, the concept of educational activities automation systematically began to develop. Within this concept, the idea originated to develop a universal multi-purpose system BIKE based on the batch processing knowledge paradigm. This allowed to focus more on educational approach, i.e. TEL educational-driven and to finish the programming of the Internet application - network for feedback (communication between teachers and students). Thanks to this specialization, the results of applications in the teaching at MTF could gradually be presented at the international conferences focused on computer-enhanced engineering education. TEL was implemented at a detached workplace and four institutes involving more than 600 students-bachelors and teachers of technical subjects. Four study programmes were supported, including technical English language. Altogether, the results *have been presented via 16 articles in five countries, including the EU level (IGIP-SEFI).*

Štefan Svetský, Ph.D. - Detached workplace Dubnica n.V., Oliver Moravčík, Professor, Dr. - dean of FMST, Dagmar Rusková, Ph.D. - Institute of Engineering Pedagogy and Humanities, Karol Balog, Professor, Ph.D. - Institute of Safety and Environmental Engineering, Peter Sakál, Professor, Ph.D. - Institute of Industrial Engineering, Management and Quality, Pavol Tanuška, Assoc. Professor, Ph.D - Institute of Applied Informatics, Automation and Mathematics, Faculty of Materials Science and Technology, Slovak University of Technology Bratislava, Paulínska 16, 917 24 Trnava, Slovak Republic, e-mail: stefan.svetsky@stuba.sk, oliver.moravcik@stuba.sk, dagmar.ruskova@stuba.sk, karol.balog@stuba.sk, peter.sakal@stuba.sk, pavol.tanuška@stuba.sk

Key words

Technology Enhanced Learning, Computer Assisted Learning, Batch Knowledge Processing

Introduction

The beginning of TEL development is linked with teaching at the detached workplace in Dubnica nad Váhom in the period of the Slovak Republic's EU-accession. It was necessary that time to incorporate the new EU environmental legislation, as well as the legislation for occupational hygiene and safety into the bachelor study programmes. For these purposes, the database application "Zápisnik" (Writing Pad) was used. It was proven in industry to promote technological activities. The application was used to produce additional electronic textbooks for courses of Introduction to Environmental Science, Occupational Health and Safety and Final Semester Projects. Course materials were prepared in two versions - for use on personal computers, and on the Internet for online environment. Students who did not have Internet access at home were thus able to access the information via the use of USB keys containing e-textbooks which could be then viewed on their home computers.

The database application called "Zápisník" was originally programmed to work with the *data.* The university modification of this program was needed in order to work with *information* and *knowledge*. For these purposes, in the first phase of the program, the *Virtual Learning Environment* (VLE) started, providing enough informatics tools for off-line and on-line teaching support. As a model of systematic technology enhanced learning support, *Mayes conceptualization cycle* was used. All these activities were presented at the eLearning Conference ICETA 2007-2008 [1, 2]. The training materials developed were also presented.

A breakthrough in the further development of TEL was the invitation to the international consortium of twenty partners, which was connected with the Partner Search brought to the Brokerage event in Warsaw [3]. MTF participated in the project proposal of the "*Knowledge Enhanced Proactive Learning Library*" (KEPLER) within the FP7-IST call "*Digital libraries and technology-enhanced learning*" [4]. One of the tasks of the MTF was the *batch processing* of "*knowledge keywords*" according to technical standards and classifications. Although the project was not accepted, MTF started a systematic research of TEL, based on the strategy of *knowledge automation* as an essential element that defines teaching and learning, respectively, acting in educational theories. From the informatics aspect, this resulted in programming the editor for *batch processing of information and knowledge* (BIKE - Batch Information and Knowledge Editor). With the help of this system, several applications in education described below were carried out.

Principles of technology enhanced learning

In real life, a teacher simultaneously needs to perform a large number of sub-educational, administrative and other activities. Moreover, this relates to various *professional contents*, different *pedagogical approaches* and *teaching concepts*. This variability and diversity of the human mind and mental processes makes the technology support very complicated. In terms of computer support (enhancements), the problem is the fact that teachers and students work with *unstructured* information and knowledge.

Another problem is that there is *no universal informatics format*, and a specific problem is *how to concentrate the large amounts of specialized content in a small screen area* while the number of possible solutions and further outputs is increasing enormously. In other words, software algorithms must be written for data, information and procedures that are *not fixed in advance*, i.e. are *variable* and usually *unknown* at that time. This is the fundamental difference, when compared e.g. to writing programs for accounting, where accurate structures, procedures and calculations are stated by the legislation.

Current approaches to the application of digital technologies for learning

Technology enhanced learning is, of course, complicated because it is an interdisciplinary field. Education has its own *distinct content* (curriculum, course of study, syllabus, engineering content) and its *educational* and *teaching practices* taking place in *real environment* (class, teaching space, library). The digital technology has its own *Internet and communication technologies* and *informatics tools* (hardware, software, and the Internet).

Success or effectiveness of technology-enhanced learning always depends on the alignment of education and technology (informatics) components, i.e. on *integrating informatics tools in learning activities*. Unfortunately, computers were not invented for education, so this area represents a major challenge for the Internet and communication technologies. The relationship between *education, digital technology, technology-enhanced learning* and *learning (educational) activities* is shown schematically in Fig. 1.

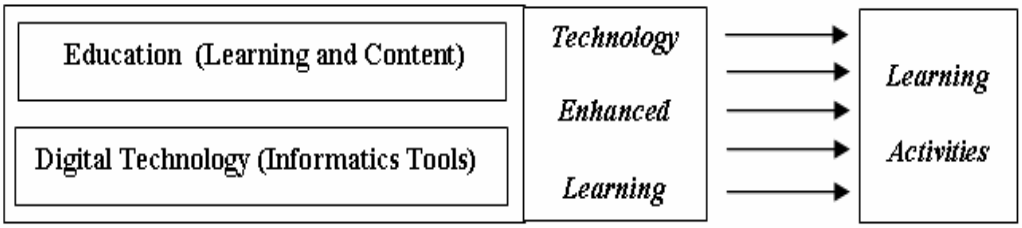

Fig. 1 *Principle of interplay between the educational component and informatics tools for TEL*

For these reasons, the technological support has undergone several stages. The related terms are such as *Computer aided instructions* (CAI), or attributes like *computer assisted / based / aided / supported learning.*

In the EU research programs, the 7th Framework Program in particular, this topic which is now called *Technology Enhanced Learning* (TEL) dominates [5]. Its definition is very broad, because it "*refers to the support of any learning activity through technology*". Deferring from that of eLearning, TEL usually confuses many people. According to Wikipedia [6] and Answers.com [7], *learning activities* can be described in terms of the *learning resource, actions, context, roles, and learning objectives*. The focus in TEL is on the *interplay* between these *activities* and respective *technologies*. *Learning management systems* (LMS), *learning content management systems* (LCMS), *learning repositories* or *managing the learning process of learners with technical means* (e.g., tools for self-directed learning, etc.) shall be appointed as *technological tools for TEL* allowing the access from educational resources to systems.

This informative description suggests that it is a preferred *technology-driven* approach even though it mentions that learning activities "*can follow different pedagogical approaches and didactic concepts*". The above-mentioned requirement of the alignment of education and technology (informatics) parts is disrupted because *technology-driven* approach is superior to the *educational-driven* approach. This fact has been recently criticized in several scientific publications stressing that the educational-driven approach should be prioritised [8, 9, 10]. This stems from the fact that teacher, and not a computer, plays a key role in the learning process.

Technology-enhanced learning approach at MTF

The basis of the theoretical outcome for the TEL approach at MTF is the idea presented at the Brockerage event in Warsaw, where MTF was looking for a project leader support [3]. This idea is based on the needs of the practitioners involved in *research* and *development* or *working with information and knowledge*, denoted as "*R&D staff*" including *researchers, teachers, librarians and students* who, in their daily practice, perform various activities requiring the processing of large amounts of knowledge and dynamic information flow. This is why "they should be equipped with information tools (digital technology) just as today's soldiers are armed with high-tech".

It should be noted that learning activities performed by teachers are much larger than those placed on the sites for TEL, i.e. as mentioned in the previous section [Cordis/ICT, Wikipedia, Answers.com]. Being a teacher, one must *study* the case itself to know how to *explain it well* and to be able to *create* a *well-construction* of *new knowledge*. Teachers at universities are also required to *publish, deal with projects, correct and mark tests, handle administration matters, communicate* with AIS (university LCMS) and alike. The TEL approach is thus based on the fact that all these activities *should be automated,* and digital technology is a *teacher's* "*partner*". In optimum cases, teacher or user needs *one universal software* that automates *everything what is possible* at the given time and space,. Such an "*all-in-one*" system was developed in the period of 2007-2010 and tested in teaching bachelor students. The working version of this system or rather the universal database application is named *BIKE* (Batch Information and Knowledge Editor). As its title suggests, it allows bulk work with information and knowledge, what IT scientists call "*batch processing*". The paradigm of work is described more closely in [12, 13]. If we correctly understand Saljö [11], the BIKE can be categorisedas so called "*Mindware*" group, i.e. software is "*linked with our body and mind*".

In principle, the BIKE editor works so that the knowledge is defined in the "informatics way" allowing the *concentration of information and knowledge at a given time and space* and is used according to the *instant need* of a certain *activity carried out* by a teacher or student. This *activity* may involve *designing* educational materials, *teaching* in a classroom with computers, *creating* eLearning configurations, *conducting* Internet retrieval, *managing the* knowledge, *marking* tests, etc. This "*bottom up*" method of work takes the user as an individual, encouraging one's mental activities such as *knowledge structures, knowledge retention, repetition and decision-making*. Thus, the software is versatile and can do what otherwise would have to be done with dozens of current software packages. With some exaggeration we can say that it works "like a chip" connected to our brain. According to current theories of learning approaches, it acts as a social memory of an individual (teacher,

student, and customer) [11]. Such an approach to the application of digital technology in education is in a very good compliance with the learning theories, both based on simple *behaviourism* or *cognitive* and *constructive* approaches. This compliance is assured by the possibility to create knowledge structures, while knowledge is constructed by using optional menu of BIKE. It only up to the user if he performs "simple things", creates sophisticated knowledge, or knowledge clusters on his computer.

It should be noted that computers were not developed to educate and most of common approaches are *mechanically applied* to support teaching and learning. However, the TEL approach based on the BIKE editor is being developed and tailor-made for individuals who work with knowledge. It does not handle new algorithms or semantic structures, but it uses the power of existing database technologies and common programming. The TEL approach at the MTF is based on *empirical* research coming out of the fact that the matters are dealt directly in teaching and technology is adapted to what one needs in a certain (educational / learning) situation. This approach thus respects the synergy of teaching content (e.g. engineering curricula), educational activities and technologies as shown in Fig. 1. The key feature in the educational process is either *teacher* (teacher-centred process) or *student* (student-centred process) and the technology is *integrated into their activities* according to how they run it and not vice versa.

Such understanding and implementation of TEL approach allows the functions to be used as technology support for all possible types of learning e.g. *self-directed learning, distance learning, blended learning, active learning and life-long learning*, ... (some applications are described below). Therefore, the BIKE editor can be used for various specific purposes and can be further developed as a *"never-ending story*". Although BIKE is characterized in this paper as a tool/software for TEL, it can be included in the category of software for so called TPACK framework [14, 15] – it is a complex interplay of three primary forms of knowledge: Technology (T), Pedagogy (P) and (A) Content (C) Knowledge (K).

Applications of technology-enhanced learning at the MTF

As mentioned above, in the initial phase of implementing TEL at the MTF, the *technology - driven* approach predominated due to the fact that it was first necessary to develop a set of information tools the teacher can choose from according to particular learning activity. In this stage, the activities were focused on the development of a knowledge base, i.e. on generating educational materials in the form of html files. These were placed in computers in classrooms and on the Internet. Gradually, as the programming environment of BIKE was growing, other types of programs have been applied to enhance blended learning, active learning, language support, batch Internet retrieving, creating a virtual library and interactive and self-evaluation tests [16-20]. At this stage, the *educational-driven* approach begun to dominate, where the teacher decides what is needed to support the daily activities.

Figure 2 shows some examples of computer screen output from teaching the subject of Introduction to Environmental Science. The Figure shows that the set of educational materials includes various types of educational output elements (navigational template for entering the e-textbooks, a sample of written semester paper, the scheme for photosynthesis, an explanation of pH, and photos of matriculation). During this time, students cannot recognize whether it is a link from the Internet, home computer or the MTF server.

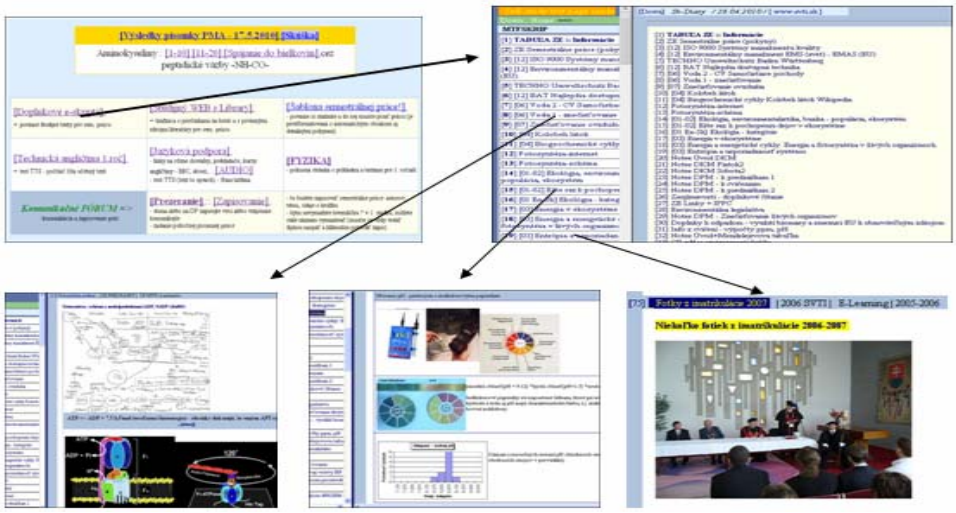

Fig. 2 *Sample of technological support for teaching the subject - Introduction into Environmental Science*

Fig. 3 shows an example of modelling a study-room for Blended Learning with pop up menu (see output to manual for semester project and a study area in the classroom).

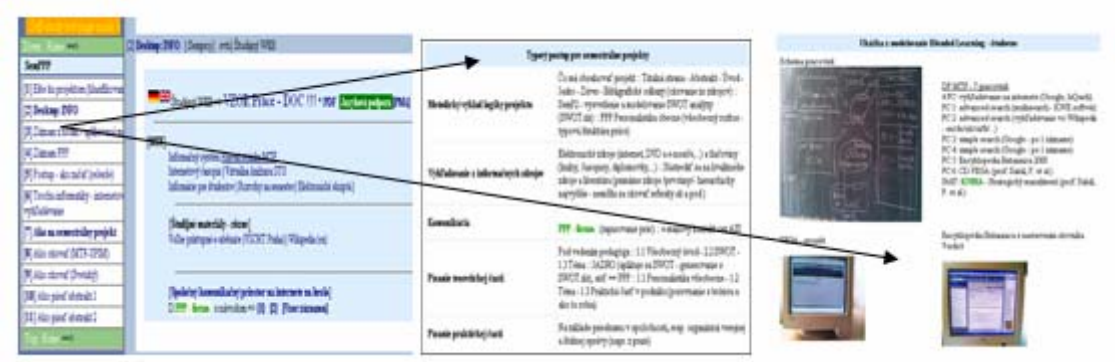

Fig. 3 *Example of modelling the study- room for Blended learning for semester project (Svetský, Sakál)*

A breakthrough in the implementation of TEL at the MTF was collaboration with the language department (Reháková and Rusková). In phase 1, a universal support site containing the links to language translators, dictionaries, the BBC course of Slovak Radio, model sentences with prepositions used in technical German and sample sentences for writing English and German abstracts for term papers and projects were developed [21, 22]. Phase 2 was cooperation with external software for Text-To-Speech (the machine says the English written text) which supported the teaching of technical English [23, 24].

Fig. 4 illustrates a popup menu which is displayed when you click on multilingual translators Google (left), Systran (centre), and scanned passive sentences (right) from the book ”Angličtina pre vedeckých pracovníkov - Dušeková, L., Bubeníková, L., 1971”.

Fig. 4 *Sample of technology-enhanced multilingualism*

Conclusion

The article presents the history of five-year implementation of *technology-enhanced learning* at the Faculty of Materials Science and Technology. The principles of technology-enhanced education from the point of current approaches in the world and TEL approach at MTF are explained. The Application of digital technologies for learning requires the alignment of *technology* (ICT tools) and the *educational component* (content of knowledge). The TEL approach chosen at MTF solves this issue by developing its own software - BIKE programming environment, which serves as a tool to automate the processing of knowledge to all possible kinds of learning activities that are undertaken.

The state-of-the-art in TEL is characterized by technology-driven approach. It is characterized by top-down testing of the approved software fit for education by assuming a universal indefinite content. The TEL approach at MTF comes out directly from the nature of knowledge as an essential element of education and is based also on educational theories and the fact that knowledge, respectively its structures, are not only managed but also created and constructed (they are transmitted e.g. via instructions from the tutor to the student). From an informatics point of view, it is solved on the basis of the paradigm of the batch processing of a knowledge flow concentrated in a certain time and space (class, virtual learning space). From a pedagogical point of view, information and knowledge are processed especially for conditions of blended and active learning, but also for self-directed and informal learning.

This TEL approach allowed the universal use of the database BIKE application in several study programmes, including language (see the preview of applications). As a technological enhancement, it has so far brought benefit to over 600 students from several MTF institutes. The results of the TEL approach in teaching were presented in 16 publications in Slovakia and abroad (Europe, North and South America, Australia). The further development aims to support more sophisticated educational applications, which will require new approaches and the programming of further textbooks, together with their verification in teaching (these are partially elaborated, e.g. advanced search, natural text marking, batch processing of chemistry calculations and social mini-network with retrievals for undergraduates).

References:

[1] SVETSKY, S. Modelling of Multilingual e-Learning and Virtual Learning space for R&D Staff. In *ICETA 2007 : 5th Int. Conference on Emerging e-Learning Technologies and Applications.* Košice: Elfa, 2007, pp. 1-4. ISBN 978-80-8086-061-5

[2] SVETSKY, S., MORAVCIK, O., TANUSKA, P., REHAKOVA, A., RUSKOVA, A. Modelling of Multilingual e-Learning and Virtual Learning space for R&D Staff. In *ICETA 2008 : 6th International Conference on Emerging e-Learning Technologies and Applications*. Košice: Elfa, 2008, p. 347. ISBN 978-80-8086-089-9

[3] SVETSKY, Š. *Multilingual self-E-learning in support of sustainability.* Online. ATVN-EU-GP-Warszaw [cit. 2011-02-15]. Available at <http://www.atvn-eugp.pl/broker/resource/ stefan_svetsky.pdf>.

[4] SVETSKÝ, Š, MORAVČÍK, O., TANUŠKA, P., SCHREIBER, P., ŠUJANOVÁ, J. *Vedomosťami podporované vzdelávanie v e-aktívnych knižniciach : Záverečná správa k prípravnému projektu 7. rámcového programu APVV - PP7RP-0054-09*. Trnava: MTF STU, 2009.

[5] TeLearn - European research on technology-enhanced learning [online]. ICT Research in FP7 - Challenge 8: ICT for Learning and Access to Cultural Resources. [cit. 2011-02-15] Available at <http://cordis.europa.eu/fp7/ict/telearn-digicult/telearn_en.html>.

[6] Technology-enhanced learning [online]. From Wikipedia, the free encyclopedia [cit. 2011-01-11]. Available at < http://en.wikipedia.org/wiki/Technology-Enhanced_Learning>

[7] Technology-enhanced learning [online]. Answers.com® [cit. 2011-01-11] Available at <http://www.answers.com/topic/technology-enhanced-learning#ixzz1D1tPmHuD>.

[8] Laurillard, D. (2008), Technology Enhanced Learning as a Tool for Pedagogical Innovation. Journal of Philosophy of Education, 42: 521–533. doi: 10.1111/j.1467-9752.2008.00658.x

[9] VUORIKARI, R., BERENDT, B. *Study on contexts in tracking usage and attention metadata in the field of multilingual Technology Enhanced Learning.* [online]. Portál people.cs.kuleuven.be. [cit. 2011-01-11]. Available at <http://people.cs.kuleuven.be/~bettina.berendt/Papers/TEL_context_attention_vuorikari_berendt.pdf>.

[10] DERRY, J. Technology-Enhanced Learning: A Question of Knowledge. In *Journal of Philosophy of Education*, 42: 505–519, 2008. doi: 10.1111/j.1467-9752.2008.00638.x

[11] SALJÖ, R. Digital tools and challenges to institutional traditions of learning: technologies, social memory and the performative nature of learning. Journal of Computer Assisted Learning. Special Issue: 'CAL'– Past, Present and Beyond. Volume 26, Issue 1, pp. 53–64, 2010. DOI: 10.1111/j.1365-2729.2009.00341.x

[12] SVETSKÝ, Š., MORAVČÍK, O., SOBRINO, D. R. D., ŠTEFÁNKOVÁ, J. The Implementation of the Personalised Approach for Technology Enhanced Learning. In *WCECS 2010 : Proceedings of the World Congress on Engineering and Computer Science 2010*. Volume I. San Francisco, 2010. - Hong Kong : International Association of Engineers, 2010, pp. 321-323. ISBN 978-988-17012-0-6

[13] SVETSKY, S., MORAVCIK, O., TANUSKA, P. Some aspects of the technology enhanced learning in engineering education. In *Proceedings of the Joint International IGIP- SEFI Annual Conference 2010*.

[14] TPCK - Technological Pedagogical Content Knowledge – TPCK [online]. Portál tpck.org [cit. 2011-03-11]. Available at http://www.tpck.org/tpck/index.php?title=Main_Page>.
[15] MISHRA, P., KOEHLER, M. Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. [online]. Michigan State University, 2006. [cit. 2011-03-11]. Available at <http://punya.educ.msu.edu/publications/journal_articles/mishra-koehler-tcr2006.pdf>.
[16] DIVJAK, B., BEGIČEVIČ, N., MORAVČÍK, O., SVETSKÝ, Š. Bilaterial collaboration for ICT support in engineering education. In *Proceedings of the Joint International IGIP-SEFI : Annual Conference 2010.* Diversity unifies - Diversity in Engineering Education, 19th - 22 th September 2010. Trnava, Slovakia. - Brussel: SEFI, 2010. ISBN 978-2-87352-003-8
[17] SVETSKÝ, Š., SAKÁL, P., HRDINOVÁ, G. Nové prístupy k riešeniu automatizácie činností výskumníkov, pedagógov a manažérov pri spracovávaní a manažmente informácií a vedomostí. In *Fórum Manažéra*, 2010, č. 1, s. 9-12. ISSN 1336-7773
[18] MORAVČÍK, O., SVETSKÝ, Š., HORŇÁK, F., SOBRINO, D. R. D., ŠTEFÁNKOVÁ, J. Experiences with the Personalised Technology Support for Engineering Education. In *21st Annual Conference of the Australasian Association for Engineering Education & 2010 Fall CDIO Collaborators´ Meeting*. Sydney: University of Technology. *The 21st Annual Conference for the Australasian Association for Engineering Education : Proceedings of the 2010 AaeE Conference*. Australia. Sydney: The Faculty of Engineering & Information Technology, University of Technology, 2010, pp. 532-538. ISBN 978-0-646-54610-0
[19] SVETSKÝ, Š., PAULÍKOVÁ, A., BALOG, K., MORAVČÍK, O., REHÁKOVÁ, A., TUREKOVÁ, I., TANUŠKA, P. Modelovanie technologickej podpory vzdelávania pre oblasť integrovanej bezpečnosti. In *Environmentálne a bezpečnostné aspekty požiarov a havárií : Konferencia s medzinárodnou účasťou.* Trnava: AlumniPress, 2009, s. 239-250. ISBN 978-80-8096-080-3
[20] SVETSKÝ, Š., BALOG, K., ŠENOVSKÝ, P. Informačná podpora integrovanej bezpečnosti. In *1. medzinárodná vedecká konferencia Policajnej, zabezpečovacej, hasičskej a záchranárskej techniky*. Trenčín: Trenčianska univerzita Alexandra Dubčeka v Trenčíne, 2009, s. 1-6. ISBN 978-80-8075-398-6
[21] REHÁKOVÁ, A., SVETSKÝ, Š. Modelovanie foriem viacjazyčnej podpory výučby s podporou IKT. In *Modernizace výuky cizích jazyků pro zvýšení konkurenceschopnosti absolventů VŠ* : Mezinárodní seminář pořádaný 16.září 2009 v rámci IX. mezinárodní konference "Liberecké ekonomické fórum 2009". Liberec: Technická univerzita v Liberci, 2009. ISBN 978-80-7372-501-3
[22] SVETSKÝ, Š., REHÁKOVÁ, A., RUSKOVÁ, D. Cudzie jazyky v technickej praxi. In *Strojárstvo – Strojírenství,* 2009, roč. 13, č. 7-8, s. 79-8. ISSN 1335-2938
[23] REHÁKOVÁ, A., SVETSKÝ, Š. IKT podpora pri výučbe jazykov. In *Transfer*, 2009, roč.1, č. 3, s. 15. ISSN 1337-9747
[24] REHÁKOVÁ, A., RUSKOVÁ, D., SVETSKÝ, Š. Modeling multilingual support systems for trainee teachers of technical branches via the use of ict. In *Problemy doksztalcania i doskonalenia zawodowego nauczycieli.* Radom: Instytut Technologii Eksploatacji, 2009, pp. 219-223. ISBN 978-83-7204-851-6

Reviewers:

Eduard Kostolanský, Professor, Ph.D. – Faculty of Natural Sciences, University of SS, Cyril and Methodius in Trnava

Anton Kachaňák, Assoc. Professor, Ph.D. – Faculty of Machining, Slovak University of Technology Bratislava

Pavel Važan, Assoc. Professor, Ph.D. - Institute of Applied Informatics, Automation and Mathematic, Faculty of Materials Science and Technology, Slovak University of Technology Bratislava