**P. J. ŠAFÁRIK UNIVERSITY**
**FACULTY OF SCIENCE**
**INSTITUTE OF PHYSICS**
**Park Angelinum 9, 040 01 Košice, Slovakia**
www.science.upjs.sk

**Jozef Hanč, Marián Kireš, Dušan Šveda**

# *The digital literacy and key competencies as the cornerstones of primary and secondary education modernization active learning in science using ICT*

**Paper**
Proceedings of the 8th International Conference on Emerging eLearning Technologies and Application
(27th - 29th October 2010, The High Tatras, Slovakia)



**How to cite:**
HANČ, J., KIREŠ, M., & ŠVEDA, D. (2010). The digital literacy and key competencies as the cornerstones of primary and secondary education modernization. In: JAKAB, F. (Ed.), Proceedings of ICETA 2010 (October 27-29, 2010, Stará Lesná). Košice: elfa., pp. 411–416. ISBN 978-80-8086-166-7

ICETA2010

International Conference

# 8th International Conference on Emerging eLearning Technologies and Applications

Editors: František Jakab
Graphical Layout: František Rakoci
Publishers: elfa, s.r.o., Park Komenského 7, 040 01 Košice, Slovakia
Printed by: elfa, s.r.o.


ISBN 978-80-8086-166-7

# Information and Communications Technologies in Education

# CONFERENCE PROCEEDINGS

**Conference is held under the auspices of**

**Eugen Jurzyca,**
Minister of Education, Science, Research and Sport of the Slovak Republic

**Anton Čižmár,**
Rector of Technical University of Košice, Slovakia

and

**Slovak Rectors Conference**

**The Conference is organized in co-operation with:**

- Communication Technology Forum, Slovakia (www.ctf.sk)
- SANET, Slovak Academic Network Association, Bratislava, Slovakia (www.sanet.sk)
- IT Association of Slovakia, Slovakia (www.itas.sk)
- Faculty of Electrical Eng. and Informatics, Technical University of Košice, Slovakia (www.fei.tuke.sk)
- Faculty of Informatics and Information Technologies, Slovak University of Technology, Bratislava, Slovakia (www.fiit.stuba.sk)
- Jyväskylä University of Applied Sciences, Finland (www.jamk.fi)
- Cisco Systems Slovakia / Networking Academy Program in Slovakia (www.cisco.sk, www.netacad.sk)
- The American Chamber of Commerce in The Slovak republic (www.amcham.sk)

**Hosted by:**
Congress Centre of the Hotel Academia,
Stará Lesná, The High Tatras,
Slovakia

**Organised by:**
elfa, s.r.o., Košice,
Slovakia

## CISCO NETWORKING ACADEMY PROGRAM

**MODERNISATION OF EDUCATION AT PRIMARY AND SECONDARY SCHOOL IN SLOVAKIA**

# THE DIGITAL LITERACY AND KEY COMPETENCIES AS THE CORNERSTONES OF PRIMARY AND SECONDARY EDUCATION MODERNIZATION

*8th Int. Conference on Emerging eLearning Technologies and Applications*

*The High Tatras, Slovakia October 28-29, 2010*

Jozef Hanč, Marián Kireš, Dušan Šveda
Pavol Jozef Šafárik University in Košice
Faculty of Science
Moyzesova 16
Slovakia
jozef.hanc@upjs.sk, marian.kires@upjs.sk, dusan.sveda@upjs.sk

Abstract. Technology dramatically changes all areas of human activity in modern society. These changes also require changes in education of young people so they will be able to learn, live and work successfully today and especially tomorrow. We present key ideas how the digital literacy, key competencies and what model of developing ICT skills became the cornerstones of modernization of education at primary and secondary schools in Slovakia realized in currently running national projects. Our introduction is supplemented by particular examples and list of references which can bring other important pieces of information for interested readers.

Keywords: Digital literacy, Pedagogy, Modernization of education, Key competencies, Skills

## 1. INTRODUCTION

In the early part of the twentieth century, education focused on the acquisition of literacy skills like simple reading, writing and calculating. Today digital technologies change our lives and society in such way that the skills demands for work and active successful life have significantly increased.

However, information and knowledge are also growing at a speed as never before in the human history. The time is long past when educators and teachers could teach students all things they need to know. Now the only viable and realistic goal of education is to put our digital-age students on their own intellectual feet - to develop skills which will be needed for them to learn, live, and work successfully today and tomorrow. According to International Society for Technology in Education (www.iste.org) the key skills for 21st century are:

1. *Creativity and Innovation:* demonstrating creative thinking, constructing knowledge, and developing innovative products and processes using technology.
2. *Communication and Collaboration:* use digital technologies to communicate and work collaboratively to support individual learning and contribute to the learning of others.
3. *Research and Information Fluency*: applying digital tools to gather, evaluate, and use information.
4. *Critical Thinking, Problem Solving, and Decision Making:* using critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.
5. *Digital Citizenship:* understanding human, cultural, and societal issues related to technology and practice legal and ethical behaviour.
6. *Digital Literacy:* demonstrate knowing, understanding and applying ICT concepts, systems, and operations, effectively, productively and creatively.

This key-skills-development philosophy of education (described in Slovak in [1]) also became a cornerstone of the currently running Slovak national project "Modernization of education at primary and secondary schools". The primary goal of the project is to raise awareness and capability of more than 6800 in-service Slovak teachers how modern digital technologies can change classrooms into modern student-oriented environments to train, develop and enhance required student's skills. In next sections of that article we would like to describe project efforts in a more detailed way.

## 2. TECHNOLOGY VERSUS PEDAGOGY

The project training framework was divided into three phases: the first two ones are directly connected with getting competence in using modern ICT (see more in [2]), the third one is specifically oriented to applying ICT in primary and secondary school subjects – mathematics, geography, science (physics, biology, chemistry) and humanities (history, music, Slovak language and literature, arts). For all training phases teams of experts have written textbooks - training instructional materials. Particular examples [3], [4], [5] of textbooks for math, science and humanities, published a few months ago, are described in English in [6], [7], [8].

However it is important to realize that the extensive educational research [9] has shown in many cases that the effectiveness of digital technologies depends strongly on the pedagogical ways in which teachers use them. One consequence of this fact is that it is insufficient to use technology without a sound pedagogy. Therefore in general, our instructional materials, guidelines and examples emphasize [10]:

- keeping the focus on the fundamental use to engage and motivate students rather than the specific mechanics of the constantly changing technology, regardless of the brand of technology used;
- using technology in ways that are consistent with appropriate pedagogy, including opportunities for active inquiry learning;
- using technology in ways that allow teachers and students to do what would otherwise be difficult to do without technology; and
- taking advantage of technology's power to engage student participation and interest.

Essentially, technology use in the classroom is most effective when it encourages deeper student engagement with content, when it is used to support rather than replace what we know about effective instruction, and especially when it stretches the boundaries of what is possible in the classroom. To get better idea what it means to have a sound appropriate pedagogy for technology, in the following lines as an example we describe new ways, things and didactical methods developed for the interactive teaching system – a set of technologies consisting of an interactive whiteboard (IWB), a wireless tablet and a classroom response system.

As teachers begin work with IWB technology, they usually go through four fairly predictable phases which may be summed up as follows [11]:

- *Phase 0:* Only random trials (e.g. use of IWB not for actual teaching, but at presentations in case of prominent visitors or special events)
- *Phase 1:* To start using IWB regularly, teachers persist in doing old things in old ways (e.g. writing notes and diagrams as in case of a regular blackboard; using scanned materials; lessons not saved at the end of classes; working in isolation not sharing resources with others)
- *Phase 2:* As they starts to understand technology, teachers continue doing old things, but in new ways. (e.g. greater use of flipchart – style lessons prepared in advance, greater use of dragable, layered objects, using resources on the web; effective use of IWB software; saving lessons for future use)
- *Phase 3:* As they begin to master the technology, teachers gradually trying new things in new ways (e.g. using videos, audio records, pc simulations for explaining; using and zooming in high-resolution photos to inspect hidden details; interactive use of software; performing virtually impractical or dangerous experiments; using real-time video communication like Skype or videoconference, use IWB as a promoting tool for classroom response systems)

Especially the phase 1 is very painful, since doing exactly the same things with an unfamiliar IWB as with a traditional blackboard is much more time consuming and more risky. Therefore phase 1 and 2 should be quickly overcome if teacher want to be satisfied with IWB and never return back to the traditional blackboard.

On the other hand any way of using (old or new) technology should be consistent with research on human learning and knowing like constructivism theories, active learning principles [1,9] or the learning pyramid [12], which describes learner's ability to retain new learning that students can recall after a day as a result of being taught by the indicated teaching method.

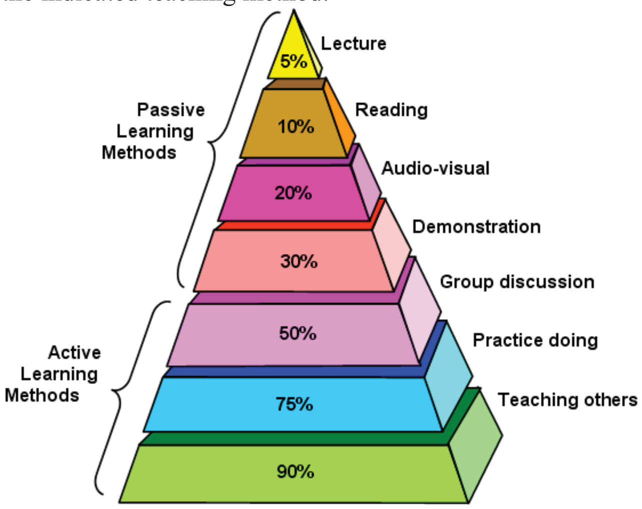


Fig. 1. The learning pyramid

An example of a new teaching successful method fully following benefits of active learning and the learning pyramid is Peer Instruction (PI) originated by Eric Mazur from Harvard [13]. This method was developed in connection with classroom response systems that belong to technologies that allow teacher to get immediately student responses to questions posed during class. How does PI work? The instruction is divided into blocks where the structure of time is determined by short, conceptual multiple-choice questions called conceptests, example of which is in Fig. 2 (often formulated experimentally or in terms of a video, audio or simulation).

A jet flies in a region of the Earth where the magnetic field points nearly straight upward. Which part of the airplane becomes negatively charged?

A. Its nose
B. Its tail
C. Its top
D. Its bottom
E. Its left wing
F. Its right wing
G. No part becomes charged

Fig. 2. An example of conceptual question

Such conceptests can be answered successfully only in case of understanding - memorizing is ineffective. Each block of a lesson (Fig.3) starts with a brief presentation or activity, which is typically devoted to the explaining, summarizing or exploring of one fundamental concept in given subject.

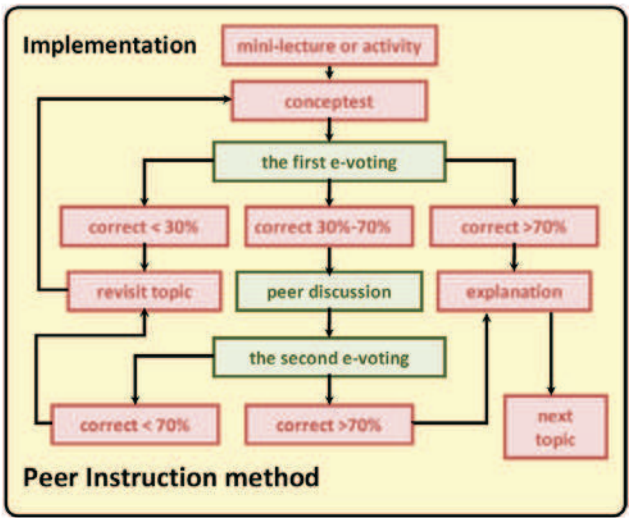


Fig.3. The procedure of PI implementation

After a brief mini-lecture, instructor poses a conceptest to students. The students individually think about answers (1-2 minutes) and submit their responses in the first e-voting using small devices called clickers which usually look like television remote controls or simple cell-phones. The special software on the computer produces a bar chart showing distribution of students' answers to make students' thinking visible to both the students and teacher.

If an appropriate percentage (between 30% and 70%) of students answers the conceptest correctly, the instructor asks students to start peer discussions about their answers with neighbours. After several minutes students answer the same conceptest again. The instructor (or a student – volunteer) explains the correct answer and depending on the second e-voting results he may pose another related conceptest or move on to a different topic. Usually in less than ten minutes most students came in their own understanding of the question at hand. In that way technology allows teachers to pay close attention to the individual progress of knowledge, skills, attitudes that learners create in their own heads. At present Peer Instruction is successfully and widely used method at all school levels, almost in all school subjects.

## 3. KEY IDEAS DEALING WITH INSTRUCTIONAL MATERIALS FOR TEACHERS' TRAINING

How can students build and test their own skills mentioned in introduction effectively and deeply in classrooms of our trained teachers? One possible way is to apply, develop and train all ICT key skills (representing the digital literacy) in all subjects at primary and secondary schools. But we can do it better. If we carefully choose only some ICT key skills which are typical and the most significant for the given subject, then we will have more time for training and developing them in more consistent and deeper way.

It means that a more specific model of ICT key skills has to be applied. The solution was offered in the original work of British educators [14] and it is representing the ICT key competencies from article's introduction by the following pie diagram (Fig. 4):


Fig. 4.

The model concentrates on developing ICT key skills, representing the digital literacy, in four areas:

- discovering and exploring the world around us by ICT
- creating and developing new ideas to understand the world around us by ICT
- exchanging and sharing obtained information with others by ICT
- critical thinking, problem solving, deciding and reviewing work at any stage

Each area is then subdivided into next three ICT key sub-skills (Fig.5.)

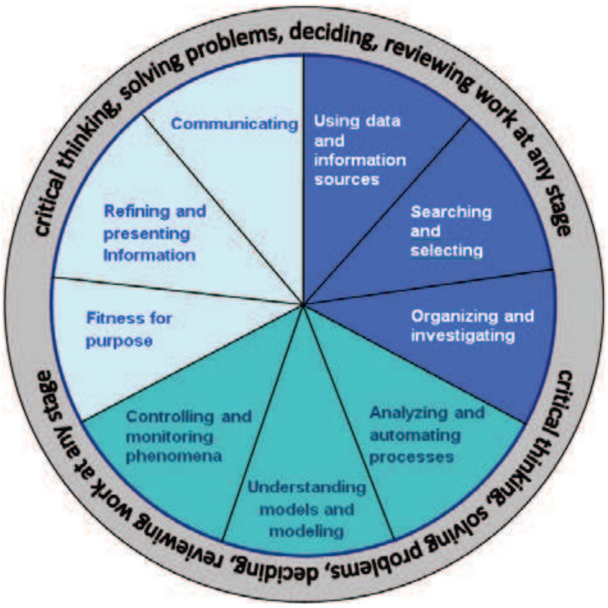


Fig.5

The resulting ten ICT key skills describe the breath of ICT capability and progression in learning any non-ICT school subject. At the same time it provides a very useful tool when discussing what key skills are most efficiently developed and on the opposite how the skills can enhance teaching and learning in given subjects.

To illustrate how and which ICT competencies have been chosen for school subjects as dominant and significant for developing, training and using, we presents two examples [8,7]: physics as one of science subjects (Fig. 6) and Slovak language as an example of humanities (Fig.7). Situation in other subjects has been summarized in Tab. 1.

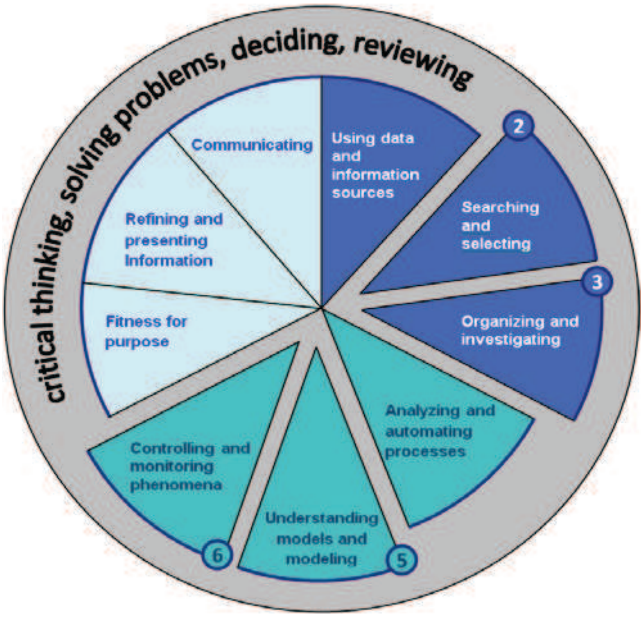


Fig. 6

As we can see that each subject concentrates on four ICT key competencies, whereas the tenth ICT key skill: the critical thinking, solving problems, deciding and evaluating work as it progresses is a fundamental feature of ICT capability, which is integrated through all areas and all subjects. Our competence model reasonably splits all components of digital literacy among all subjects (see Tab. 1). Math, geography and science subjects primarily develop ICT key skills from the first area – discovering and exploring the world around us. The main role in humanities is played by the third area. The middle area is overlapping.

In case of physics the four ICT key skills are particularly significant, which as students's competencies can be dominantly developed and used in physics teaching and learning:

- searching and selecting by ICT
- organizing and investigating by ICT
- understanding models and modelling by ICT
- controlling and monitoring phenomena by ICT

Therefore these four ICT key skills became determining for the structure and contents of physics textbooks for training in-service teachers [5]. Also all methodologies of lesson plans, the main result in each textbook for third phase of teachers' training are the model-oriented.

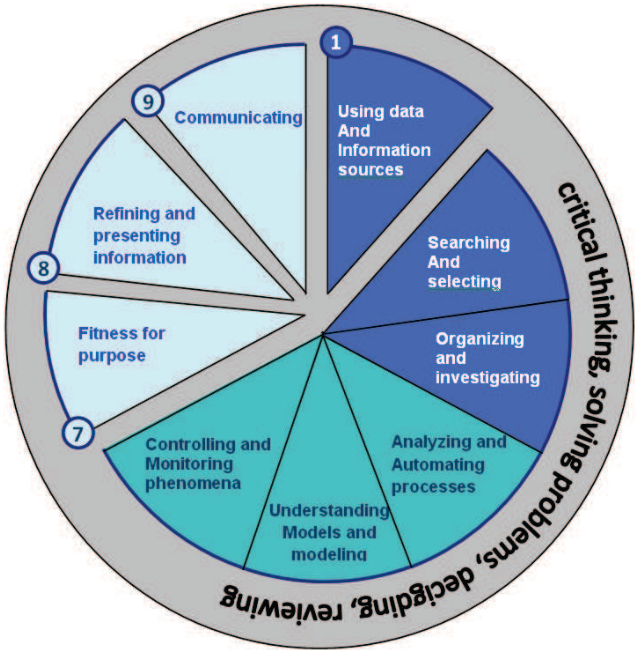


Fig.7

For better orientation which ICT competences are developed in the particular lesson we introduce an example (Fig. 8): the introductory table (common for all lessons in all subjects) of lesson material [3, 6] *What is correlation*? intended for teachers of mathematics at secondary schools. The topic and grade determine contents and age of students corresponding to difficulty of the methodology. Objectives and pre-knowledge are formulated from the student's viewpoint.

Cells entitled competencies and didactical problem are targeted to address what pedagogical problem should be solved using digital technologies and what ICT key skills will be developed during lesson. That cells are providing us information in what area of the pie diagram we are during the teaching of our students. Finally cells Means, Methods, Forms focus on particular ICT technology and connected appropriate pedagogy. It makes easier orientating to see what technology and pedagogy have a essential role in teaching process of active engaging, interacting, exploring, developing and thinking about given topic.

In this particular theme about correlation the technology of interactive applets (pc simulations) allow students visualizing important graphical and statistical properties of relationships between data and making statistical experiments which give better understanding and statistical intuition. Google spreadsheets permit real-time, quick and efficient performance of collaborative activities together with sharing and exchanging results. In addition web technology in the form of web e-voting (e.g. www.polleverywhere.com) or LMS (e.g. moodle.org) can serve as immediate feedback to gather students' responses mapping their thinking, understanding or attitudes. All these activities would be practically impossible to do without ICT.

| ICT key skills in subjects across curriculum | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Mathematics* | x | | x | x | x | | | | |
| *Science* | Physics | | x | x | | x | x | | | |
| | Biology | | x | x | | x | x | | | |
| | Chemistry | | x | x | | x | x | | | |
| | *Geography* | x | x | x | | | | | x | |
| *Humanities* | History | x | x | | | | | x | x | |
| | Slovak language | x | | | | | | x | x | x |
| | Music | | | | x | x | | x | x | |
| | Arts | | | | x | x | | x | x | |

Tab. 1

| ***Topic***<br>What is it about? | ***Grade***<br>Who learns? |
|---|---|
| **What is correlation?** | **The third or fourth at secondary schools** |
| ***Objectives***<br>What should a student learn? | ***Pre-knowledge***<br>What should a student know before? |
| ■ to discover and understand intuitively basic properties of correlation as the measure of linear relationships between to variables<br>■ to recognize between cause-and –effect relationship and statistical relationships<br>■ to estimate a correlation value from graphs<br>■ to use graphs and correlation as an effective analysis tool for describing relationships between data<br>■ to use technology for visual data displays, statistical calculations and summaries | ■ to know what it means creating a graph from a table<br>■ to understand qualitatively basic concepts dealing with statistical relationships between variables (concepts: association, relationships; positive, negative, strong, moderate, neither)<br>■ to be familiar with using Excel's basic functions and graphs |
| ***Competencies***<br>What should a student adopt? | ***Didactical problem***<br>What will we solve? |
| ■ ICT key skill - using data and information sources with emphasis on collecting, organizing, selecting data and correct interpretation of various data representations<br>■ ICT key skill – investigating and organizing available information, analyzing data and relationships between them | ■ the traditional instruction mostly focuses on performing statistical calculations and numeric manipulations rather than understanding, interpretation and application<br>■ many students only memorize statistical concepts; ICT help solve the problems providing quick calculations, visual displays, collaborative work, immediate feedback |
| ***Means***<br>What will we use? | ***Methods and Forms***<br>How will we do it? |
| ■ spreadsheet application ( Excel, Google )<br>■ web-based e-voting system<br>■ interactive applets (Geogebra, Excel)<br>■ activity-based tutorials (printed)<br>■ real data in prepared spreadsheets | ■ guided inquiry - Workshop method<br>■ Peer instruction method<br>■ groups (recommended size: 2)<br>in a computer classroom with internet |

Fig. 8

## 4. CONCLUSIONS

The running national projects “Modernization of education at primary and secondary schools” represent the most important and biggest innovation efforts dealing with particular subject-oriented applications of ICT during the short, twenty years long history of Slovakia. At this moment national projects are at the beginning of the last third phase of teachers’ training which should be ended in 2013. Twenty textbooks with corresponding e-contents for e-teaching have been finished and published as a result of project efforts of more than 140 project experts. There is a big hope that these projects will bring positive and needed changes in Slovak primary and secondary education of present and future generations of young people to increase the significance of Slovakia at least in the European Union.

## 5. REFERENCES


[1] Brestenská, B. et al: Premena školy s využitím IKT – využitie IKT v danom predmete, spoločná časť, UIPŠ-Elfa, Košice, ISBN 978-80-8089-146-8

[2] Kireš, M., Hanč, J., Ješková, Z., Lukáč, S.: The role of digital technologies in contemporary primary and secondary education and its modernization, Proceedings ICETA 2010

[3] Lukáč, S. et al: Využitie IKT v predmete matematika pre stredné školy, elfa, Košice, 2010, ISBN 978-80-8086-149-0

[4] Sabol, J. et al: Využitie IKT v predmete slovenský jazyk a literatúra pre stredné školy, UIPŠ- Elfa, Košice, 2010, ISBN 978-80-8086-149-0

[5] Duľa, I. et al: Využitie IKT v predmete fyzika pre základné školy, UIPŠ- Elfa, Košice, 2010, ISBN 978-80-8086-149-0

[6] Hančová, M., Lukáč,S., Sekerák, J., Semanišinová, I., A: Active learning in mathematics using ICT, Proceedings ICETA 2010

[7] Andričík, M., Hevier, D., Kesselová, J., Milčák, M., Sabol, J: Active learning in Slovak Language and Literature using ICT, Proccedings ICETA 2010

[8] Ješková, Z., Duľa, I., Hanč. J., Kireš, M.
Lukáč, S. et al: Active learning in science using ICT, Proceedings ICETA 2010

[9] Bransford , J.D. et al: How people learn: Brain, Mind, Experience, and School, National Academy press, Washington, USA, 2000, ISBN 0-309-07036-8

[10] Randy et al., Technology in the secondary science classroom, NSTA Press, ISBN 978-1-933531-27-4

[11] Betcher, Ch. and Lee, M.: The Interactive Whiteboard Revolution: Teaching With Iwbs, Acer Prees, Camberwell, 2009, ISBN 0-864-31817-0

[12] Sousa, D. A. How the Brain Learns, 3nd ed., Corwin Press, London, 2005, ISBN 1412936616

[13] Bruff, D., Teaching with classroom response systems: Creating Active Learning Environments, Joessey Bass, San Francisco, ass, 2009, ISBN 0-470-28893-1

[14] BECTA: ICT across curriculum, Curriculum and Standards, a collection of e-publications,
ICT in Mathematics, 2004, Ref: DfES 0176-2004 G
ICT in Science, 2004, Ref: DfES 0178-2004 G
ICT in Geography, 2004, Ref: DfES 0194-2004 G
ICT in History, 2004, Ref: DfES 0192-2004 G
ICT in Music, 2004, Ref: DfES 0186-2004 G
ICT in Art and Design, 2004, Ref: DfES 0188-2004 G
ICT in English, 2004, Ref: DfES 0174-2004 G
http://publications.teachernet.gov.uk/


## THE AUTHORS

**Jozef Hanč,** works as an assistant professor at Department of Physics Education at Institute of Physics, Faculty of Science, P.J. Šafárik University in Košice. He currently holds the position of the department head. His teaching responsibilities are connected to introductory courses of general physics and didactical subjects. He has received his physics PhD degree at the P.J. Šafárik University in Košice. His research work is devoted to new interactive teaching methods in science and math together with modelling and new approaches in modern physics teaching.

**Marián Kireš,** works as an assistant professor at Department of Physics Education at Institute of Physics, Faculty of Science, P.J. Šafárik University in Košice. He currently holds the position of the co-director of the Institute of Physics, responsible for education. He has received her PhD degree at Faculty of Mathematics, Physics and Informatics, Comenius University, Bratislava. He deals with using multimedia in education, experimental problems solving, conceptual understand and inquiry-based science learning methods.

**Dušan Šveda:** works at the P.J. Šafárik University in Košice, Faculty of Science, Institute of Mathematics, where he teaches didactical subjects and Geometry. He has obtained his PhD degree at the Comenius University in Bratislava in program Theory of mathematics education. Later he was habilitated at the Constantine the philosopher University in Nitra. His research is especially devoted to modern methods in teaching mathematics using ICT. Currently he works at the UPJŠ in Košice as a vice-dean for development of Faculty of Science.

## ACKNOWLEDGEMENTS


*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.*