TEACHING MATH WITH ADVANCED LEARNING BLOCKS

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ABSTRACT

A new role of a teacher for the 21st century is here. As stated in numerous papers this new role means that teachers should be oriented more towards guiding the learner through the learning process. In this process information and communication technology (ICT) plays a significant role. So it is not surprising that more and more e-resources are available to be used in the learning process. But through analyzing existing resources we often find that the authors of resources do not use the opportunities offered by the new technologies. One of the most important drawbacks of the existing resources is that authors too often forget (or neglect the fact) that teachers are the ones who will guide the learner through the resources.
Recent studies have shown that teachers need e-learning content that they can easily adapt and reuse for their own purposes. This means that lessons should be made out of small learning blocks or, as they are also called, "knowledge objects". A new concept of how to create really useful e-learning content has evolved in Slovenia; namely, by "putting the teacher back into the game". The selection of proper technologies and tools for managing e-learning content and the establishment of a user-friendly and easy-to-use environment for creating and modifying e-learning content, are essential to ensure basic support and popularization of e-learning.
In this talk, we will present new ideas with proofs of concepts of "modular, really interactive e-content" build on the top of the mathematical knowledge using open-source solutions, open standards and some programming. E-learning content, which will be discussed, is not intended to be an electronic teaching book, but the add-on to the standard learning material. Some preliminary results can be seen at http://www.nauk.si.

Keywords

E-learning content, educational content preparation, modular blocks, ICT in math teaching

INTRODUCTION

The world is changing rapidly, but the educational system is not keeping pace. The currently prevailing educational model is still the same as the one established in the 19th century, developed to meet the needs of industrial economy. At the time, there were a certain number of children in the classroom, who were all taught in the same way, using the same approach and the same teaching materials (Robinson, 2009; Banathy, 1991; education, 2010).

The children sitting in the classrooms of today are different. Using information and communication technology is something completely natural for them. Computers and communication devices are ubiquitous to them (Prensky, 2001; Lusoli & Miltgen, 2009; Evans, 2007).

The current public education systems continue to assert that a "one-size-fits-all" full time classroom-based model can and will effectively serve all students (Robinson, 2009; Banathy, 1991). However, just as everything else, education needs to be customized. We live in a society where everything is individualized and personalized: computers are built to our exact specifications; we personalize our mobile phones with ringtones, wallpapers, skins, etc. Students, on the other hand, are repeatedly taught in the same way. If we take into account the fact that students are progressively becoming an increasingly heterogeneous group, mostly due to the lifelong learning initiative and that even in age homogenous group not all students are learning at the same pace, benefiting most from the same environment, following the same learning path, and using the same methods, it soon becomes apparent that an individualized approach is absolutely essential.

So the amount of "ex cathedra" lecturing is steadily diminishing. The role of the teacher in the 21st century needs to be redefined. Teachers at all stages of education should be oriented towards guiding the learner through the learning process. They are no longer “walking encyclopedias” or “talking textbooks” (Rodrigues & Kitchen, 2005) – this role has recently been successfully replaced by the internet. Instead, teachers are planners, strategists, researchers, pedagogical diagnosticians, work organizers, counselors, tutors, etc. Their main task is to guide a learner through pieces of information (teaching resources) towards knowledge, with the requirement to concretize the educational content and adapt it to the interests and abilities of a particular learner (Johnston-Wilder & Pimm, 2004).

We will focus on how this need for individualization is addressed by the development of the teaching materials used in the educational process.

ORGANIZING AND USING TEACHING RESOURCES

The phase of organizing and choosing teaching resources is one of the fundamental steps in the learning process. At this step the teacher actually makes the decision how the learning process will be performed. It is at this step that important factors, such as the class we are teaching, the pedagogical situation and other numerous issues that influence the learning and teaching process are taken into account.

It is very rare that teacher is in s a situation in which his chosen teaching material is a certain textbook which is used from the first page to the last one. Usually combinations of different

materials are used. Workbooks, tasks, pages on the Internet, etc, are chosen. There are countless choices to be made.

Have you as a teacher ever considered how great it would be if you could have a slightly different textbook with a different sequence of examples, with a certain part omitted, some parts added from another source, etc.? Only rarely do we encounter a learning situation where there exists an "ideal" resource, say a textbook that can be used without any change whatsoever. Why? Authors of resources (workbooks, for example) envisage a hypothetical (ideal) pedagogical situation with hypothetical students. But the actual teaching process always differs at least slightly from the hypothetical one that the author had in mind. Since good teachers use resources in the most appropriate way, they are forced to combine and adapt various resources available.

What about e-resources, e.g. resources that use modern information communication technology (ICT)? As more and more teaching resources are available in this form, we should expect a teacher's task in managing the resources to be getting easier. Unfortunately, this is not usually the case.

There is a conflict between the possibilities technology provides, the teachers' wishes and the e-materials available. These e-materials are often so technologically "closed" that there is no tool such as the scissors and duct tape that are used when "recombining" classic, printed materials. All too often the e-materials are monolithic blocks (or at least their main parts are). This demands that the teacher takes them as a whole, precisely in the order they were prepared. Many projects focusing on the development of e-resources are complete portals where navigation through the resources must be followed in the exact way the author(s) had imagined. We encounter web portals with embedded flash animations, heavy and sophisticated usage of frames, applets without the source, which are impossible to adapt, etc. So teachers encounter problems if they want to use only a part of the e-materials, not to mention the fact it is usually not possible to adapt the materials at all. And we claim that such e-resources do not exploit all pedagogical potential technology brings into the educational process.

In the design of e-resources the role of the teacher as the one who makes the final combinations of the e-resources is all too frequently neglected. The authors of the task usually focus solely on the students. They make decisions in which order the content should be presented, what the examples should be, how many of them, where it is suitable to require the student to do a certain number of exercises, what the responses should be, and any further steps in the event of wrong solutions … Where is the role of teacher? Is it not his/her primary task to interact directly with the students, performing decisions which resource and in which way should be used at a certain moment? When e-materials are constructed as a whole, the teacher is required to use them in the order prescribed by the author. Why not use the possibilities offered by new technologies and at least give the teachers the chance to adapt the materials to their and their students' needs. The teacher comes into direct contact with the student, so he is the one who can decide which materials would be appropriate for the situation given. And this possibility of the modification will raise the quality and the value of the resources.
Using an analogy to toys – a ship made of Lego® bricks has a far greater pedagogical potential as pre-constructed, unchangeable models.

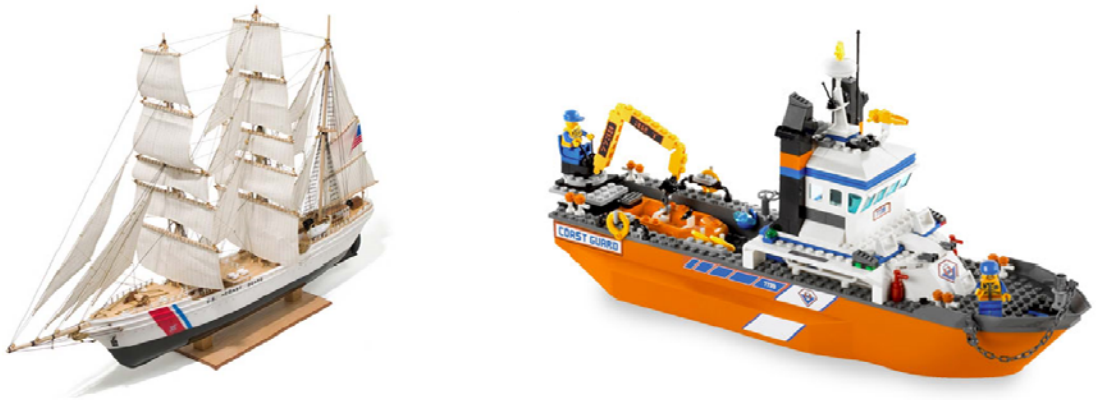

Figure 1: Different model – different pedagogical potential.

A DIFFERENT APPROACH TO MATH RESOURCE DESIGN

Several studies have shown that teachers need e-learning content that can easily be adapted and reused (Hwang, 2008). As can be seen, a conflict exists between the possibilities offered by the technology, the teachers' wishes and the e-materials available Therefore, the selection of proper technologies and tools for managing e-learning content and the establishment of a user-friendly and easy-to-use environment for creating and modifying the content, are essential to ensure the support and popularization of e-learning.
We need small, flexible units covering small pieces of subject taught. They should be available in different formats, as there are numerous learning environments and learning situations. And the authors of the resources provide (beside those small units) a combination of those units as their idea how a certain combination could look like. But mostly this is just an idea, a proposition. Teachers will adapt those models according to a particular learning situation.

The primary concerns of the authors of e-materials should therefore be:

- creation of basic building blocks (units),
- development of pre-combined models (that can be corrected or recombined), and
- provision of guidelines for the construction of new models.

What represents a basic building block depends on the particular learning situation. It can be a short explanation of a concept, a picture, an animation, a short video clip, a question, an exercise, an interactive game, etc. But there is more. The basic building blocks themselves should offer the possibility of being adapted, as well. The teacher should be able to reword a question, change the explanation slightly, add a link to another material on the topic in the feedback, and so on; in short, the teacher should be able to improve the building block itself.

NAUK.SI – A PRACTICAL EXAMPLE

This part will show how concepts described above could be used in practice in preparing modern, high quality mathematical educational e-materials. Motivated by interviews with numerous teachers, who expressed their wish to be "in control" of the resources and following the analysis

of the before mentioned research, an informal research group called NAUK was established. The word “nauk” means “education” or “lesson” in Slovenian, and is at the same time an acronym for NApredne Učne Kocke – Advanced Learning Blocks.

One of the aims of the group was to create an innovative web-based application for managing and serving e-learning content tailored to the needs of teachers. Teachers can choose between various animations, worksheets, question banks, dynamically generated questions and thus develop their own learning path. Each resource is supported by a brief explanation and a short preview. All resources can be freely downloaded in various formats.

Another thing that has previously been neglected by other content creation tools is the process of knowledge extraction. Teachers do not only want some basic quiz type questions but often want to randomize questions, offer feedback for the most frequent errors, use structured questions that challenge the learner and therefore construct a nonlinear path through the process of examination and learning. Since each question is a knowledge object, all this is possible with the NAUK system. Finally, the authors of the content have generally been people trained in ICT. Because teachers with little or no practice in the use of ICT should be able to use the software, it was designed to be very intuitive and user-friendly.

The NAUK group is currently involved in several projects in progress that are concerned with the creation of e-learning content for high-school mathematics, elementary- and high-school physics, elementary-school logic, all pre-faculty levels of computer science classes and faculty-level mathematics (see Figure 2)

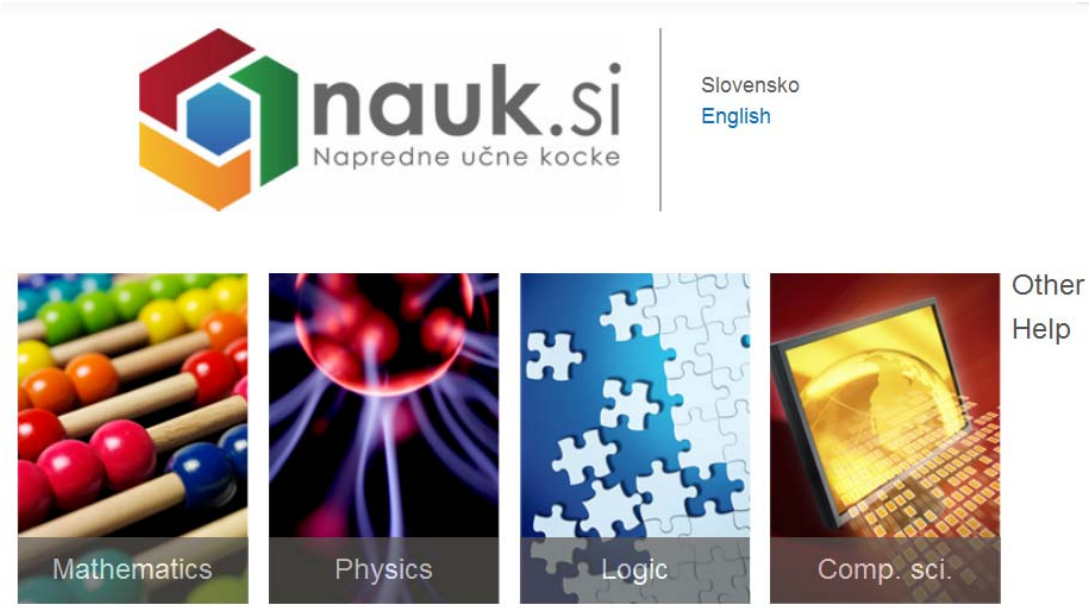

Figure 2: The entry page of the NAUK repository.

The basic idea of NAUK’s approach can yet again be easily compared to the popular Lego® bricks; see Figure 3. The e-learning material should be built by creating: basic / simple building

blocks, pre-designed e-learning material, which can later be customized, by using instructions for preparing customized e-learning material combining simpler building blocks.

Figure 3: Analogy of the NAUK learning blocks paradigm with the LEGO® bricks.

By using the NAUK services the teacher is able to take an existing content from the repository, adjust or supplement it, and publish it immediately in the repository. Therefore, the teacher is no longer obliged to blindly follow the ideas of the original authors of the content, but is able to adapt the content to his or her needs. He or she can easily:

- take a few questions from the existing quizzes and make a new quiz,
- add or improve responses (feedback) depending on the accuracy of the answer to a question or an interactive part of the teaching material,
- take a previously constructed teaching material, remove or replace a certain section, change the order of chapters and slides, etc.,
- correct an animation or add his or her own example,
- assemble a context aware test from a database of questions, where the next question displayed depends on the accuracy of the answer to the previous question,
- add leaps in the learning pathway and thereby build a non-linear learning structure.

CONCLUSION

Teaching resources should be designed in a flexible way, supporting appropriate use of different ICT tools. Teachers should have the possibility to adapt resources respecting the knowledge, skills and needs of their students. The teachers have the right to be included in the e-learning process by preparing the content for their students.

REFERENCES

Balanskat, A., Blamire, R., & Kefalla, S. (2010). The ICT Impact Report, A review of studies of ICT impact on schools in Europe, Retrieved June 15th 2010 from http://insight.eun.org/shared/data/pdf/impact_study.pdf.

Banathy, B. H. (1991). *Systems design of education: a journey to create the future*, Englewood Cliffs, NJ: Educational Technology Publications.

Bryan, A. (2006). Web2, A new Wave of Innovation for Teaching and Learning?, *EDUCASE review*, Retrieved June 15th 2010 from http://www.educause.edu/ir/library/pdf/ERM0621.pdf.

Carlgren, I., Handal, G., & Vaage, S. (1994). *Teachers' minds and actions: research on teachers' thinking and practice*, Washington, DC: The Falmer Press.

CERI. (2009). Beyond Textbooks: Digital Learning Resources as Systemic Innovation in the Nordic Countries, *OECD 2009*, Retrieved June 15th 2010 from http://www.oecdbookshop.org/oecd/display.asp?CID=&LANG=EN&SF1=DI&ST1=5KSJ0TFD5DQ5.

education. (2010). In *Encyclopædia Britannica*. Retrieved July 01, 2010, from Encyclopædia Britannica Online: http://www.britannica.com/EBchecked/topic/179408/education.

Elliot, J. (1993). *Reconstructing Teacher Education*, London, The Falmer Press.

Evans, J. (2007). Tomorrow's Students: Are We Ready for the New 21st-Century Learners?, EDUCAUSE Podcast, *EDUCAUSE 2007 Annual Conference*, Retrieved July 01, 2010, from http://www.educause.edu/blog/gbayne/E07PodcastTomorrowsStudentsAre/167251.

Hwang, D. (2008). EDUNET: The Core of Korea's Knowledge Bank, *presentation at 2nd Strategic meeting EdReNe*, Lizbona, June 2008, Retrieved June 15th from http://edrene.org/seminars/seminar2Lisbon.html.

IML. (2009). Teaching Matters: A handbook for UTS academic staff, Retrieved June 15th 2010 from http://www.iml.uts.edu.au/learnteach/resources/tm/teacherprep.html.

Johnston-Wilder, S., & Pimm, D. (2004). *Teaching secondary mathematics with ICT*, McGraw-Hill International.

□einy, S. (2002). *Ecological thinking: a new approach to educational change*, Lanham, MD: University Press of America.

Kissing, M. (2008). KeyShop – a new culture of learning, *Progress report of GRUNDTVIG Multilateral project*, Retrieved June 15th 2010 from http://eacea.ec.europa.eu/llp/projects/public_parts/documents/grundtvig/gru_134022_keyshop.pdf

Lokar, M. (2000a). Some questions about technology and teaching, in Exam Questions and Basic Skills in Technology-Supported Mathematics Teaching, *Proceedings of the 6th ACDCA Summer Academy in Portoroz (Slovenia)*, bk Teachware Series: SL-15.

Lokar, M. (2006). Electronic teaching and learning resources in math teaching in Slovenia, In D. Quinney (Ed.), *Proceedings of the 3rd International Conference on the Teaching of Mathematics at the Undergraduate Level*, Istanbul, Turkey. Hoboken, NJ: John Wiley.

Lusoli, W. & Miltgen, C. (2009). Young People and Emerging Digital Services. An Exploratory Survey on Motivations, Perceptions and Acceptance of Risks, *JRC Scientific and Technical Reports* (Sevilla: EC JRC IPTS) (EUR 23765 EN), March 2009, Retrieved June 15th 2010 from http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=2119.

Palfrey, J., & Gasser, U. (2008). *Born Digital: Understanding the First Generation of Digital Natives*. Basic Books.

Parker, K., & Chao, J. (2007). Wiki as a Teaching Tool, *Interdisciplinary Journal of Knowledge and Learning Objects*, 3. Retrieved June 15th 2010 from http://ijklo.org/Volume3/IJKLOv3p057-072Parker284.pdf.

Prensky, M. (2001). Digital Natives, Digital Immigrants. *On the Horizon*. MCB University Press 9(5) 1-6. Retrieved 15 June 2010 from http://unesdoc.unesco.org/images/0013/001390/139028e.pdf.

Rodríguez, A. J., & Kitchen, R. S. (2005). *Preparing mathematics and science teachers for diverse classrooms: promising strategies for transformative pedagogy*, Routledge.

Robinson, K. (2009). We Are the People We've Been Waiting For, Retrieved June 15th 2010 from http://www.wearethepeoplemovie.com/.

Varlamis, I., & Apostolakis, I. (2006). The present and future of standards for e-learning technologies. *Interdisciplinary Journal of Knowledge and Learning Objects* 2, 59-76, Retrieved June 15th 2010 from http://ijklo.org/Volume2/v2p059-076Varlamis.pdf.