The National
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REPUBLIC OF SLOVENIA
MINISTRY OF EDUCATION,
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Investing in your future
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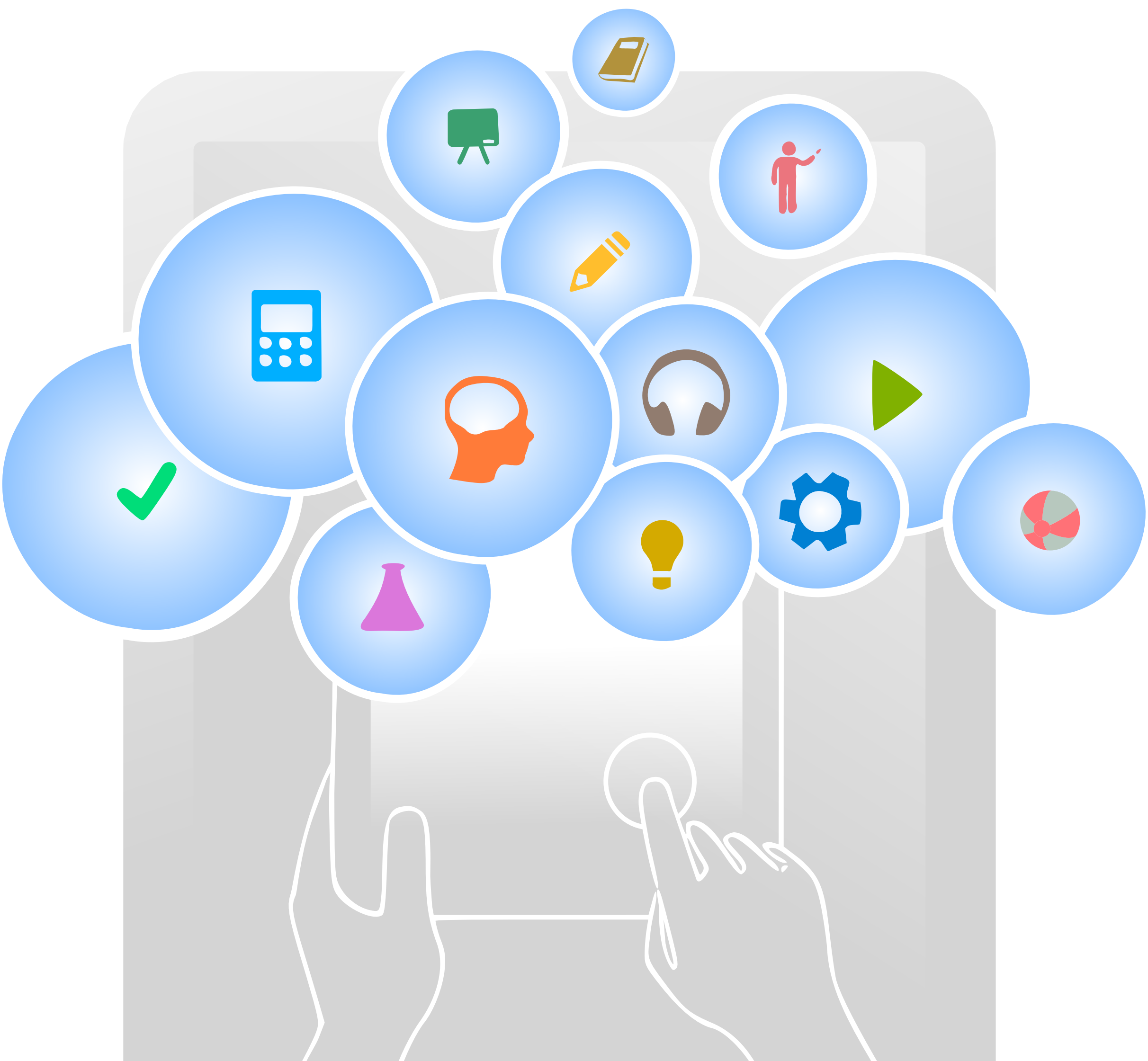
European Social Fund

Slovenian i-textbooks

Editors: Igor Pesek, Blaž Zmazek, Vladimir Milekšič



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Foreword

Gregor Mohorčič

In the international arena, all school systems and all organizations concerned with the development of education (OECD, EU), are constantly dealing with the request and at the same time desire to improve the quality of the school system. By connecting and sharing of practices and taking into account the domestic and international conceptual papers and research which are putting forward a pupil, which needs to be empowered and able to live and work in the future society in which adaptability and learning will be essential. The pupils should therefore be encouraged to develop skills needed to work (cooperation, negotiation, decision making, search, selection, structuring and evaluation of information), to learn and be innovative (critical thinking, learning, problem solving, creativity, intellectual curiosity) and to live (citizenship, global awareness, career, personal and social responsibility). At the same time it is necessary to continue to develop skills in academic subjects.

That the Slovenian educational institutions (hereinafter referred to as schools) can respond to all these challenges a switch from the "classical school" to the "innovative school" or a school of the future must be made. Teacher experts are working in the schools of the future. They are using problem-based approach, are flexible, use feedback on their work, create an optimal climate, have a deeper understanding of learning and teaching, accompany the student's problems and evaluate their level of understanding and give qualitative feedback to the students.

The schools of the future lead the learning; they design, implement and maintain a strong innovative learning environment where changes can occur; they are dominated by the stimulating learning climate and a culture of good community, where learning is in the centre. The school is also connected to the networks and partnerships (between schools, businesses, local community, research institutions ...). This is a school that is not only a building, but the process.

On the way to the school of future following key conceptual areas are important: leadership for learning, learning environment, professional development, materials and documents, and monitoring and evaluation. These conceptual areas are interdependent, are complementary and require proper planning, effective implementation and evaluation both in a particular area and as a whole.

Learning environment comprises a stimulating climate, collaborative work, teamwork and peer support, by means of which creates a culture of good community. The learning environment is also a physical space and all the technology we recently carefully and systematically introduced into education. This technology opens up new concepts of work in educational institutions, especially the e-learning materials and e-textbooks that appeared in recent years. With the introduction of e-learning materials and e-textbooks, it is necessary to provide for the appropriate professional development of teachers and systematically monitor and evaluate the work in the schools.

The present monograph is divided into sections that describe each phase of the project E-textbooks for science subjects, and thus summarizes the activities and results of the project.

The first part presents the project E-textbooks in science subjects and gives overview of the development of e-learning materials and e-textbooks in Slovenia. The second part describes the starting points and tools to produce the e-textbooks. Design and implementation of i-textbooks are described in the third part. An article about the future plans concludes the monograph.

At the end we would like to emphasize that the realization of the project E-textbooks for science subjects can be estimated to be extremely successful, as the indicators and expected results of the project in all segments exceeded expectations. We hope and believe that the achievements / results of the project will be accepted among the learners and that the Ministry of education as soon as possible finds a solution that will allow continued development and maintenance of e-learning materials and e-textbooks in Slovenia.

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From e-materials to i-textbooks

From e-materials to i-textbooks

Igor Pesek, Blaž Zmazek, Gregor Mohorčič

This article presents the evolution of e-learning materials from the first attempts in the early days of the internet to the latest developments in e-textbooks. We present the main projects and milestones in the production of e-learning materials from 2005 to 2010. We also address issues concerning e-learning materials' licensing. The market offers a variety of e-learning materials on various technological and didactical levels; we have therefore divided them into three separate groups, with the most important called the interactive textbook or i-textbook.

Key words: interactivity, textbooks, e-textbook, i-textbook, license

Introduction

Recently, there is a lot of attention given to development of an appropriate learning environment in the field of education. This includes physical environment and all of the technology that is being systematically and thoughtfully introduced in Slovenian education system. The key to this technology is definitely not in the technological equipment of schools, even though it is also necessary and substantial, but on content and materials that can be used independently of devices (mobile phones, tablets, interactive whiteboards, computers, etc.) in school work. Corresponding materials and their use on devices, open up new work concepts in educational institutions, especially with e-materials and i-textbooks appearing recently. Concern for the development, meaningful introduction and evaluation of e-learning materials and i-textbooks use and professional development of teachers are base conditions for quality work in schools.

E-materials in Slovenia

Learning materials are an important element of the educational process, particularly when a teacher is not the sole mediator and facilitator of knowledge. In addition to the functions of storage and transmission of information and facilitating opportunities for consolidation and deepening of knowledge, they can be an effective mediator in the construction of new knowledge (Repolusk, 2009).

Development of information and communication technologies has enabled a more efficient use of e-learning materials in educational process as a result of interactive learning media (Pesek, 2011). With development of the World Wide Web (WWW) in 1992, a development of e-learning projects such as "Petra" and "Računalniško opismenjevanje" (Computer literacy) began. At the same time the Ministry of Education began with the purchase of didactic software for schools and institutions. In 1995, when Slovenia got its first instalment of the Slovenian Education Network (then http://sio.edus.si), a drafting of guidelines began for the evaluation of materials (e.g. Batagelj, 1996; Batagelj, 1999), which was linked and appeared in the repository of materials known as Trubar. Since then, the Ministry regularly organizes meetings for teachers, professors and experts in the field of ICT at the international conferences MIRK, SIRIKT, VIVID et al.

In the years 1997-1999 the Ministry opened several tenders for smaller projects for developing online e-materials, through which individuals or groups of teachers produced e-learning materials for different areas. Consultants of the National Education Institute of The Republic of Slovenia have been involved in these projects and most of the resulting e-learning materials have also been included in seminars on the use of ICT in teaching and learning. In 2006–2008 the Ministry carried out public calls for tenders for extensive online e-materials (available at http://www.sio.si) (Kreuh, 2011; Čampelj and Čač, 2011). With these calls, the Ministry wanted to include projects that were working on development of innovations in the use of ICT (introducing new ways of working with educators and teachers, and consequently students) to contribute to further development of the education system. Primary targets of these calls were new multimedia and interactive e-learning materials that are in line with the curriculum. The resulting e-learning materials and other materials are, in addition to education of teachers, also intended for free use in the educational process, i.e. supporting implementation of existing educational programs. E-materials also help reduce the use of printed materials by students. In the long run we can help reduce the cost of education of children and reduce the weight of their school bags. All e-learning materials are under a Creative Commons license, which allows the detected errors to be corrected, however, the Ministry of Education does not need specific permission (Čampelj and Čač, 2011).

Public calls for tenders for development of e-materials were defined by a series of demanding conditions for authors, editors, programmers, reviewers, proof-readers and recommendations for e-learning materials. Recommendations for e-learning materials were based on the guidelines of various international projects (European Schoolnet) in which several Slovenian experts were involved. However, these recommendations were based only on technological conditions, which can be attributed to insufficient involvement of experts in the field of didactics. An essential aspect of learning materials was neglected and thus their use, which may be a part of an answer to the question "Why are e-learning materials not used as much as we would expect them to be?" (Čampelj and Čač, 2011).

Among all of the e-materials, which were developed in public tenders in 2006-2008, e-learning materials found on the website www.eum.si (E-um, 2006) are being used more then all the others combined (33,000 users out of approx. 65,000 annual visitors used "e-um" services). Even when first e-materials were being published; professional audience wondered what the key distinction causing such a significant difference in their use was. Several multimedia and interactive e-learning materials were tendered in the context of alignment with the curriculum. Each applicant determined the proportion of coverage in the curriculum (number of hours, as well as the number of web pages, images, animations, videos, interactive elements, etc.) for each e-material. The providers of e-um materials have set to cover the syllabus in its entirety (including general, special and selected knowledge) despite lower requirements of baselines of tenders, thereby laying/forming the foundations for the development of standards for e-textbooks (Hvala, Kobal and Zmazek, 2007; Kobal, Hvala, Zmazek, Šenveter and Zmazek 2007; Lipovec, Kobal and Repolusk 2007; Zmazek, Kobal and Zmazek 2007; Zmazek, Kobal, Zmazek and Hvala 2007; Kobal and Zmazek 2007; Zmazek, Hvala and Kobal, 2007; Pesek and Regvat 2007; Prnaver, Šenveter and Zmazek 2007; Prnaver, Pesek and Zmazek 2007). Unfortunately, the Ministry has not accepted a proposal of unification of recommendations and baselines of e-learning materials in form of e-textbooks since the second public call for tenders in 2007.

The amendment to the guidelines for approval of textbooks in 2010 has introduced certification of e-textbooks, but the rules require only a digital format of e-textbooks. This has, in the following years, led to a certification of digitized forms of traditional printed textbooks, which is absurd, since the validation process checks the printed versions for professional correctness and alignment with the curriculum that was already established. That is how the concept of an e-textbook lost its original meaning (interactive electronic textbook) in Slovenian schools and covers all electronic textbooks.

In September 2011, based on the recommendations for development of e-textbooks (Zmazek et al., 2011; Zmazek et al., 2011b) and as a result of good practices in projects developing e-learning materials, the National Education Institute of The Republic of Slovenia released a publication titled "Izhodišča za izdelavo e-učbenikov" (Baselines for the Preparation of Electronic Textbooks) (Kreuh, Kač and Mohorčič, 2011), which should lead to a greater consistency in the preparation and validation of e-textbooks in Slovenian schools. These baselines were a basis for an implementation of the "E-učbeniki s poudarkom naravoslovnih predmetov v osnovni šoli" (E-textbooks for science classes in primary school) project, which has been implemented by the National Education Institute of The Republic of Slovenia in 2011, in framework of which several e-textbooks for science subjects and mathematics in primary and secondary schools were developed. Most e-textbooks have already been approved by the Council of Experts for General Education; the few remaining ones are currently in the process of certification.

I-textbooks

In December 2011, in the first phase of the "E-učbeniki s poudarkom naravoslovnih predmetov v osnovni šoli" (E-textbooks for science classes in primary school) project, substantive-didactic and technical-organizational baselines were formed for e-textbooks, which later became the standard for introducing the concept of **i-textbook** for a group of interactive e-textbooks.

The use of multimedia elements, questions with immediate feedback and interactive exercises and examples, offer a categorization of electronic textbooks in three levels.

The first level of e-textbooks includes d-textbooks, which is a shortened term for digitized textbooks. These textbooks are electronic copies of the traditional print textbooks and contain only text and images; they are usually in a PDF or EPUB2 format. The d-textbooks content providers usually offer different applications that enable presentation of these d-textbooks. These applications offer bookmarking options and adding notes. Some providers also offer applications for interactive whiteboards.

The second level of e-textbooks includes r-textbooks (rich e-textbooks). These textbooks are an upgrade to d-textbooks as they also include audio and video. Some r-textbook applications also offer simple questions with immediate feedback. Due to the simplicity of upgrading to an r-textbook, the majority of publishers abroad (Digitale Schulbücher, Mosaic MozaBook, etc.) choose this type of e-textbooks.

The third level includes i-textbooks (interactive e-textbooks). I-textbooks are not an upgrade to r-textbooks even though they offer same functionality. Development of i-textbooks is substantially different from all the others, technologically and content-wise. The key advantage of i-textbooks is in its direct integration of interactive examples, structures and functions in the text of an i-textbook. The feedback is of better quality, it enables storage of responses and monitoring of the user. I-textbooks are usually based on HTML5 or EPUB3 standard and are thus supported by a wide range of applications. Key highlights of i-textbooks are presented in subsequent papers of the monograph.

Figure 1 depicts all three categories of e-textbooks.

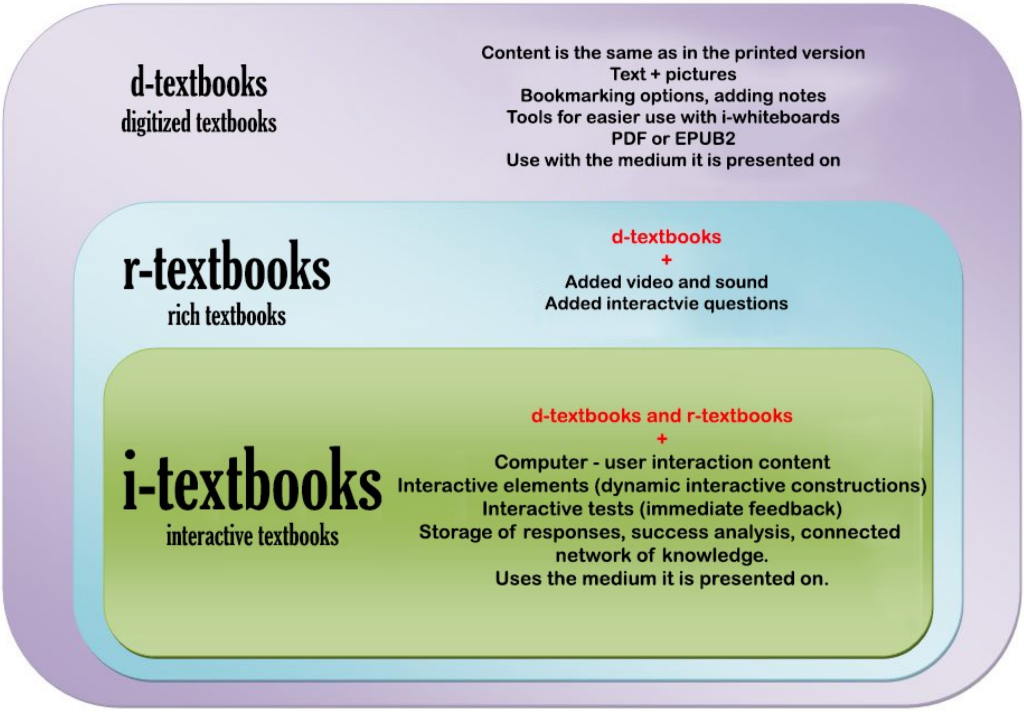

Figure 1: Categories of e-textbooks

After a successful implementation of the first part of the "E-učbeniki za naravoslovne predmete" (E-textbooks for science classes in primary school) project, the Ministry ordered a development of interactive e-textbooks for all other classes in the eighth and ninth grade of primary school and first year of high schools, amongst other activities of The National Education Institute of The Republic of Slovenia, within the project "E-šolska torba" (E-schoolbag). The beginning of the implementation revealed issues experts were already warning about in the first public calls in 2006. Since all e-materials, e-books and i-textbooks are under the Creative Commons license and owned by the Ministry, a question is raised on further development and maintenance of these constructed materials. In the first projects (2006-2008) the contractors committed to maintaining these materials for another 3 years after completion of projects already expired in 2012. The same question arises with the regard to the maintenance of i-textbooks developed in projects "E-učbeniki za naravoslovne predmete" (E-textbooks for science classes in primary school) and "E-šolska torba" (E-schoolbag). A solution to this problem would be to change the type of licensing for produced content, which would also allow commercial use, thus ensuring the maintenance and development of e-learning materials and i-textbooks.

The biggest problem seen in all previous projects, especially in the "E-šolska torba" (E-school bag) project, is caused by the use of content with recognized copyright. The rights for this content’s use (historical photographs, recordings of paintings, sound recordings etc.) cannot be purchased for use in i-textbooks, because they are licensed under the Creative Commons licence. Due to these problems, the Ministry should, as soon as possible, adopt a strategy for development, publication and maintenance of i-textbooks that would ensure the further development of i-textbooks in Slovenian schools.

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Project E-textbooks for science subjects in primary school

Igor Pesek, Blaž Zmazek, Gregor Mohorčič, Vladimir Milekšič

This paper presents the implementation requirements of the Ministry of Education and Sports, which expected the E-textbooks project to upgrade the existing e-learning materials to modern e-textbooks. The underlying technological facts, which describe the differences in the development cycle of traditional textbooks and e-textbooks are provided. The organizational structure of the project is then presented, followed by the importance of digitized curricula for teachers and a justification of the choice of a single e-textbook content format. Finally, the references to contributions in the monograph are given, which further illuminate the key substantive and technical issues of the project.

Key words: e-textbooks, description and goals of the project

Introduction

The "E-textbooks for science classes in primary school" project was launched in 2011 and is ending in 2014. It was co-financed by the Ministry of Education and Sports (MoES) and the European Social Fund. We will describe the implementation requirements of the project and technological platforms, which were set at the beginning of this project and based on the experiences of the project team working on similar projects in the past.

Ministry of Education and Sports set the following operational points in the project application documentation (translated from the project application):

Various MoES projects have produced a greater number of e-learning materials (digitized learning sets), which include different subjects, different classes and different subsystems developed on different technological platforms. It is duly reasoned to upgrade e-learning materials for subjects, which have the highest number of developed *e-learning materials. This is why we recommend an upgrade of e-materials into e-textbooks for at least 15 science subjects and mathematics in primary school. It therefore makes sense to review all created materials, to determine which syllabus goals are already included in these materials, as well as didactically and technologically unify these materials.*

Above mentioned e-materials do not include all syllabus goals, which means, that these parts of the curricula need appropriate e-learning materials to cover all the objectives of the curriculum. After this goal is completed, these materials should be upgraded into e-textbooks. This objective can be achieved by upgrading selected e-learning materials into e-textbooks. If there are no available appropriate e-learning materials necessary for this upgrade, a construction of the missing e-learning materials is required in accordance with the revised and September 1st, 2011, applied curriculum.

We need to evaluate the performance of e-textbooks in school practice and determine which conditions must be met for a school to appropriately use e-textbooks, whether teachers need any special training to use them and which conditions must students meet and whether they need any special training to use them etc. These are just a few of the issues that arise on the subject of e-textbooks. All these questions can be answered with an analysis of the use of already developed e-textbooks.

The project team ran into quite a difficult task on the very beginning of this project. It had to meet all the demands set by the Ministry and in preparation of e-textbooks use and upgrade all of the existing e-learning materials designed in previous MoES public calls. Upgrading these e-learning materials into e-textbooks would not have been so difficult, if technological and didactical content properties of existing e-learning materials would have been preserved on execution, which is what DZS and VideoFon did in the pilot project (MoES, 2011). Due to significant technological breakthroughs at the turn of the decade, at the time when first version of an iPad tablet was released and Apple completely changed the technology and user baselines in developing and using e-learning materials, it was completely senseless and irrational to insist on using technology of existing e-learning materials. The aforementioned e-textbook pilot projects were developed based on technology that is no longer supported by most modern systems, so their usefulness is very limited. This monograph presents some visionary decisions made by the project team, which perceived the direction of technological development and was able to use and implement its forth set platform in development of e-textbooks.

The goal of this project was to develop e-textbooks for the following subjects in primary school:

– Physics
– Chemistry
– Mathematics
– Biology
– Science
– Science and Technology
– Home economics

Due to development issues and concerns of the leadership in this project, didactic group and other experts, it has been decided that there will be no e-textbooks developed for the first triennium. At the same time, integration and upgrade of content in high school education had a significant impact on the decision, that for all subjects, where such integration is possible (physics, chemistry, mathematics, biology) e-textbooks will be developed.

From an editorial and publishing point of view e-textbooks are not significantly different from traditional textbooks. Development of e-textbooks does demand a higher set of computer and technical skills, which enable development and design of better and more interactive learning content. Development of e-textbooks also requires an additional step, because programmers have to prepare an e-textbook for publication on a selected medium and in an appropriate form. However, the process of developing e-textbooks and traditional printed books is the same as shown in Figure 1.

The main difference, in terms of publishing, is in life of a textbook after it has been published. The life cycle of a classic textbook ends when it is published, the only thing that remains is distribution. E-textbooks have an additional cycle that allows the publisher to monitor e-textbook use, with the opportunity to comment on a micro level (exercises, examples, descriptions), to analyse and correct published work. When changes are made to an e-textbook, all users receive an updated version of the e-textbook, which is undoubtedly a substantial advantage over traditional textbooks. Additional cycle of preparing and publishing of an e-textbook is shown in Figure 2.

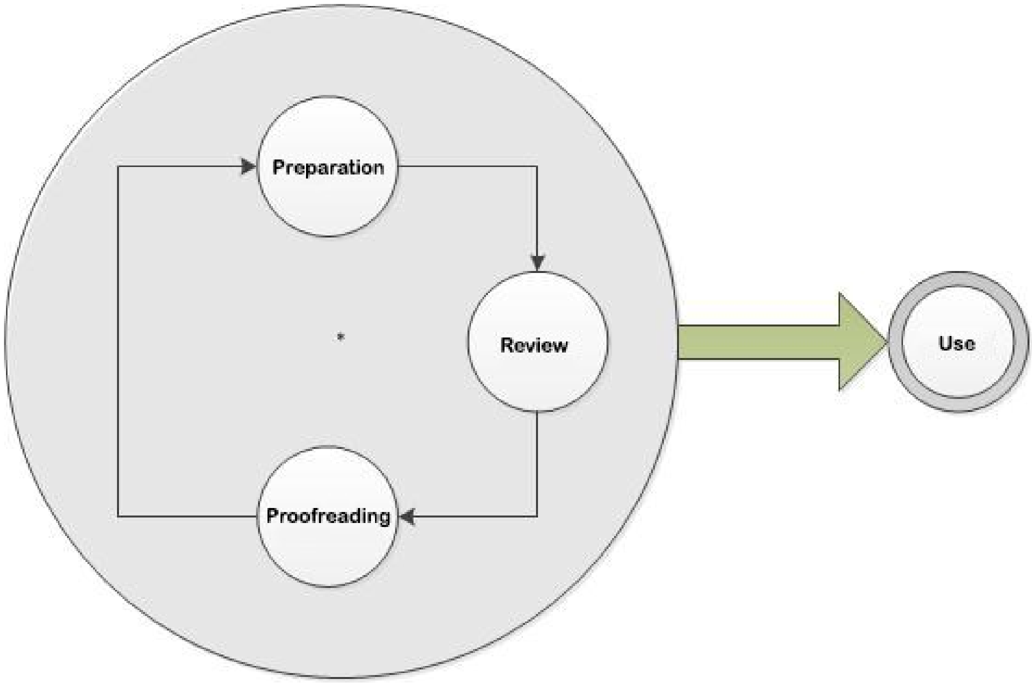

Figure 1: Main steps of e-textbook development

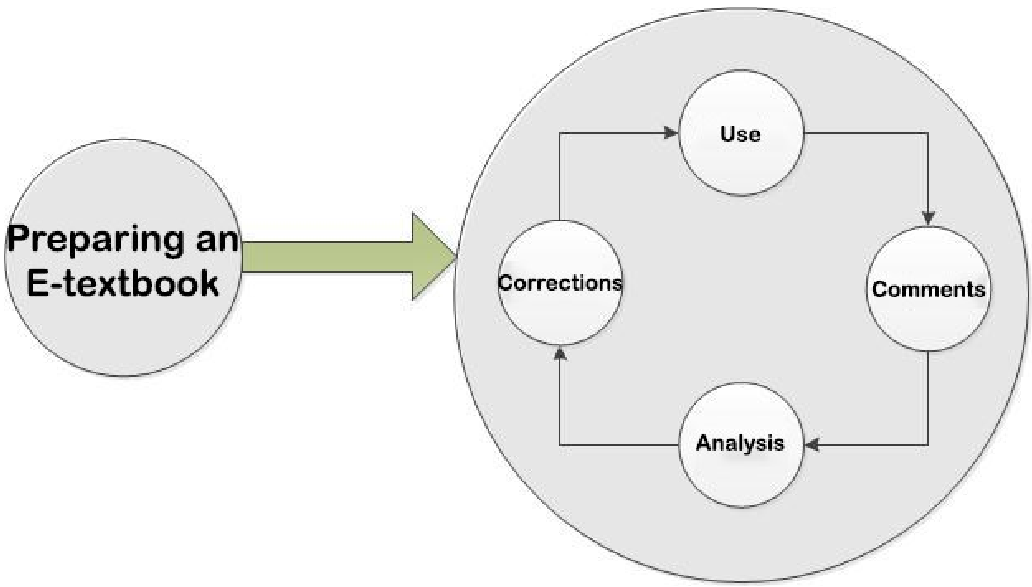

Figure 2: E-textbook improvement cycle

Organisation

The management of the project formed two groups of experts for designing substantive-didactic (Zmazek et al., 2014) and technological baselines (Pesek and Zmazek, 2014), which served as a starting point for the development of e-textbooks. Several seminars were developed and implemented for editors, authors and technical staff on the basis of these guidelines. Authors of e-textbooks have been selected on the base of their training and assessment results on seminars, which were conducted in the context of several public calls. A team led by an editor was developed for every e-textbook. The team consisted of authors, technical staff, illustrators, reviewers and consultants. The latter were responsible for substantive-didactic adequacy of content.

Organisational structure of the project is shown in Figure 3.

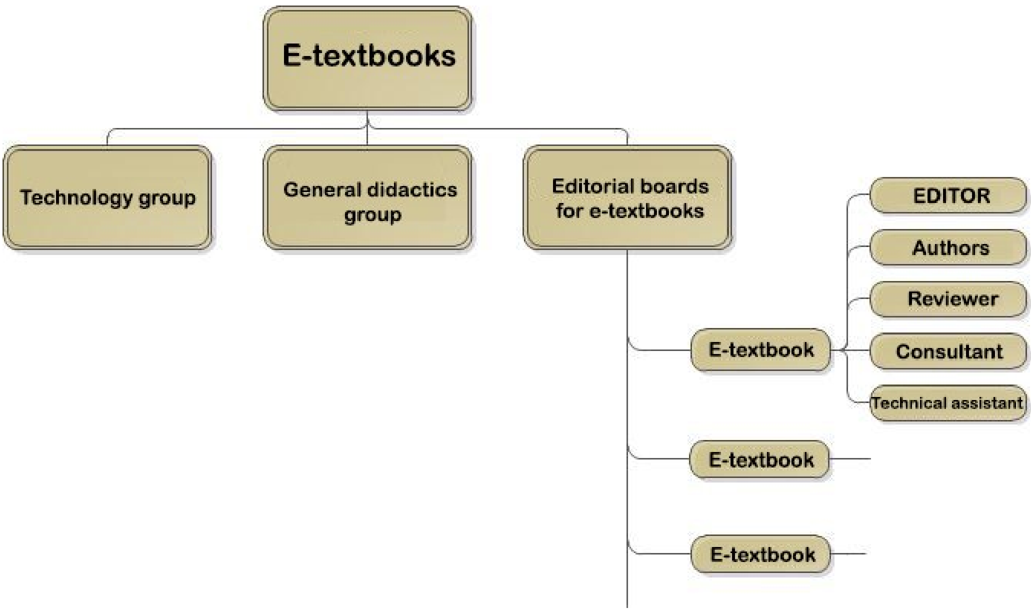

Figure 3: Organisational structure of the project

Goals

One of the criteria for approval of textbooks (traditional and e-textbooks) set by the Expert Council of the Republic of Slovenia for General Education is that textbook content must attain all goals set out in the curriculum for the subject area covered by the textbook. This is why this project involved digitization of all curriculum goals and objectives related to individual learning units and development of a two-way interconnected grid of objectives and units that can help teachers in planning lessons in the beginning of a school year, as well as in search for information and guidance during the rest of the school year. Now each curriculum objective has all units recorded and digitized.

Knowledge network

During the preparation of concepts and placement of e-learning units in e-textbooks, editors pointed out that a connection should be made between content related e-learning units, so that if a user does not understand the content or needs some definitions of specific terms, a list of e-learning units is provided (also from other classes and subjects), necessary for understanding of the e-learning unit. If a student finds the content of the current e-learning unit interesting and would like to read more on this topic, the knowledge network provides a list of e-learning units related to the current e-learning unit. An example of a knowledge network is shown in Figure 4

A universal term for such a network is "topic map" (Topic map, 1991), which is standardized, has its own XML schema and is used in the management of large volumes of content.

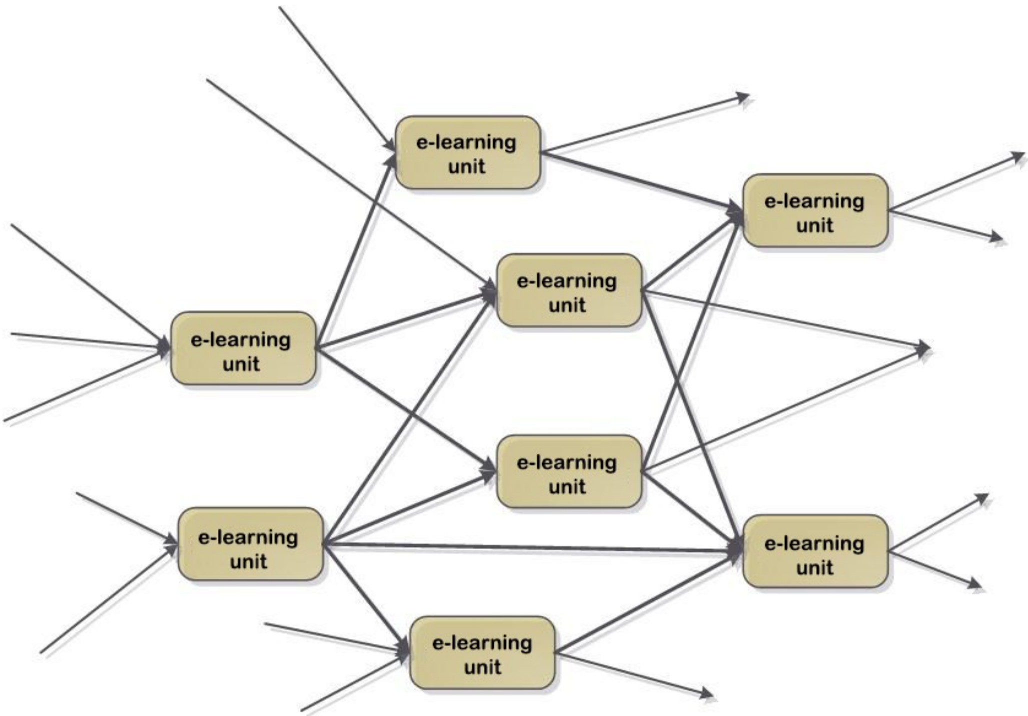

Figure 4: Knowledge network

Visual identity

One of the aspects of the project was also to unify the graphic design of all e-textbooks developed in this project. The basic aim was to offer a user experience that would not be dependent on the operating system or device. That is why we separated the content from its form by using HTML5 and CSS3 technologies. As a result, an e-textbook is no longer tied to a single design, but customizable. To change the entire design of an e-textbook one must only change the CSS file. The initial design of e-textbooks was designed by Idearna d.o.o., which has, based on our guidelines, developed a modern design of i-textbooks for science subjects. Some characteristics of the design are shown in the screenshot in Figure 5.

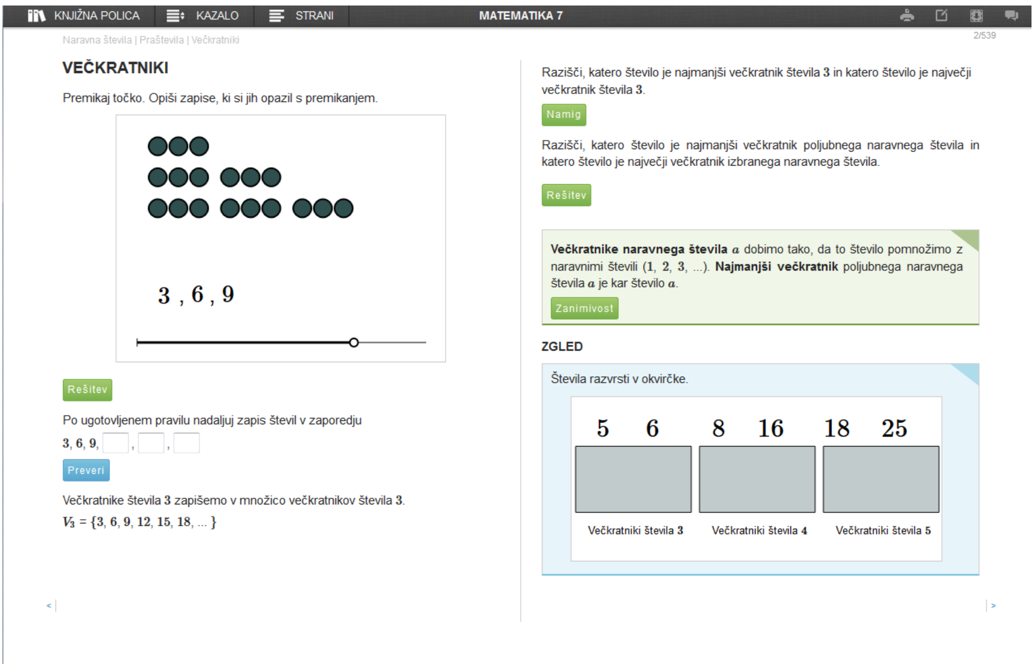

Figure 5: An example of e-textbook page design

Displaying e-books on different operating systems

At the time this monograph was being written, there were three main operating systems on the market, designed for tablet computers: Android, iOS and Windows. Most schools in Slovenia run Microsoft Windows operating system 7 or 8). Technology group (Pesek and Zmazek, 2014) has therefore been looking for the most appropriate content format and applications to display this content. This decision was based on speed, ease of maintenance, e-textbook upgrades option, add-ons and ability to function offline. Because e-textbooks could not work in web browsers without an internet connection, which was a key requirement in the development of e-textbooks, it was decided that applications should be developed for all three operating systems, which will enable all of the above stated requirements. The first application "E-torba" (E-schoolbag) was designed for the Android operating system and is available on Google Play. Screenshot of the application is shown in Figure 6. The other two applications are planned to be implemented by the end of this project.

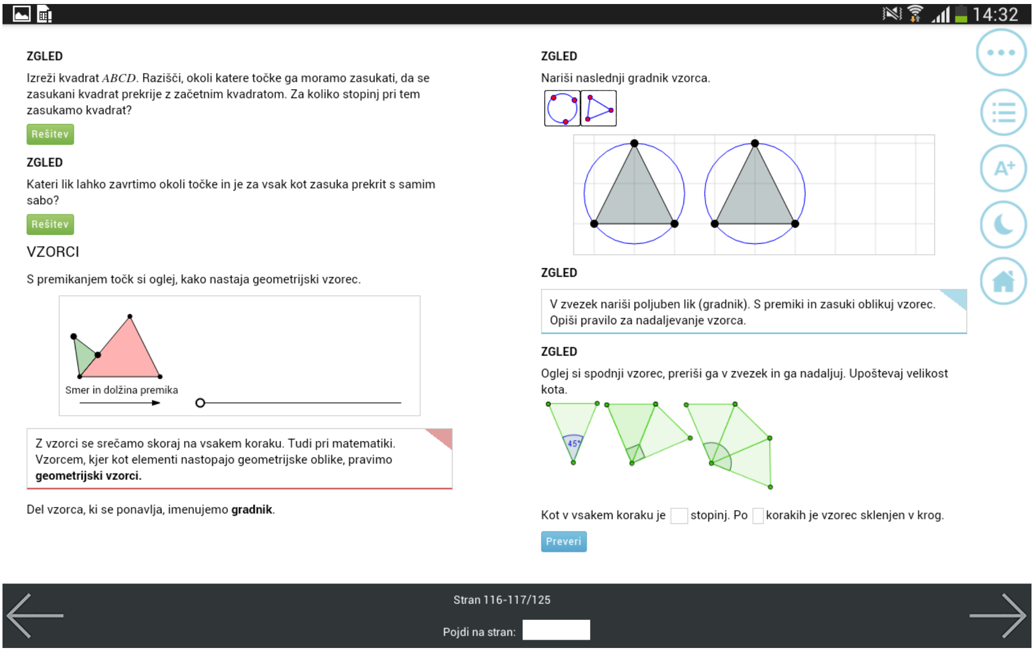

Figure 6: Screenshot of the application on Android operating system

XML - Independent data format

As experience have shown, previous tenders by the Ministry for which a unified data format was not set, led to a use of different data formats: HMTL, Adobe Flash, Java, etc. The dispersion of technologies, and several times their incompatibility, has disabled all attempts to design e-learning materials on a shared platform. That is why the technological group set a goal of unifying data format by choosing a format independent of any current technology. The group's decision was based on two similar data formats (ELML, 2008; ML3, 2007), in which similar conclusions were made. Because the two aforementioned records were missing a few key features, the technology group designed its own XML schema that describes the content in a neutral XML format called E-learning object XML or ELOX (ELOX 2013). The scheme contains tags to describe all the elements of individual e-learning units of an e-textbook. The content is written in a difficult to interpret XML format, which is why an extra step is needed to convert the content into a user-friendly format (e.g. HTML). ExeCute authoring tool is a tool that allows exporting content in an ELOX data format, but we are developing a program, which will be integrated into the administration portal of the project and will allow exporting to various formats (EPUB3, SCORM et al.).

Matura exams

Matura exams have been a high school final exam in Slovenia for 20 years. Every year, subject commissions for graduation courses prepare new assignments that are usually almost inaccessible to future generations of students. The e-textbooks project has obtained a license to download and convert all the matura exams of natural science subjects in a form and format of e-textbooks. At the completion of this project, all matura exams, with solutions and scoring criteria, will be available in all applications and on the e-textbook website.

Evaluation of e-textbooks in a pedagogical process

What happens when a class powers on 30 tablets and they all simultaneously access the Internet? What to do when tablets run out of battery in the middle of a lesson? These are technical issues that occur when tablets are introduced in a teaching process. What about content issues? When to start using i-textbooks and to what extent? How to use i-textbooks? We will try to provide answers to all these questions with an evaluation in the final year of the project. Teachers and consultants, involved in the project team, plan, monitor and develop examples of good practice that will enable a successful introduction of e-textbooks to Slovene schools in the coming years.

Conclusion

The "E-učbeniki pri naravoslovnih predmetih v osnovni šoli" (E-textbooks for science classes in primary school) project involves didactic guidelines and guidelines for development of i-textbooks (Zmazek et al., 2014), which, together with technical and organizational framework (Pesek and Zmazek, 2014) form a foundation on which future i-textbooks will be developed in Slovenia. An administrative portal has been established, which allows development of i-textbooks from a concept to a finished product. Together with other support mechanisms that enable production of i-textbooks, creating i-textbooks becomes only a creative effort (Kaučič, Prnaver, Regvat, Novoselec and Šenveter, 2014). On an international level, the project successfully connected with the leading developers of JavaScript applications for interactive geometric structures (Wasserman, Drakulic, Pesek and Zmazek, 2014). The views of the didactic group have been prepared and presented in various meetings and explained how i-textbooks can be used in the teaching process (Lipovec, Senekovič and Repolusk, 2014), how to use them specifically in chemistry (Vrtačnik and Zmazek, 2014) and how i-textbooks can be used as an excellent tool for modelling in mathematics (Lipovec, Senekovič and Zmazek, 2014). I-textbooks have been, to a lesser extent, used as a teaching tool in a classroom, the results of these tests are well described in the literature (Lipovec and Senekovič, 2014).

Because the implementation of the project proved a great potential and vision, the "E-šolska torba" (E-schoolbag) project was launched in 2013 (Flogie, Čuk, Milekšič and Jelen, 2014), which provides a great basis for the continuation of the "E-učbeniki za naravoslovne predmete v OŠ" (E-textbooks for science classes in primary schools) project.

The "E-textbooks" project brings a fresh perspective on the preparation and use of e-textbooks in Slovenia and other countries. It will enable an introduction of the currently most feasible pedagogical paradigms, such as class free schools, and any other new educational approaches in the future.

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Baselines and support for i-textbooks development

Substantive-didactic baselines and instructions for i-textbook development

Blaž Zmazek, Igor Pesek, Vladimir Milekšič, Samo Repolusk, Jožef Senekovič, Alenka Lipovec

Learning materials in today's schools are increasingly exploiting electronic media to mediate the construction of knowledge. Among these, electronic textbooks play an important role, which specifically takes advantage of the interactive capability of modern electronic media. In this paper we define the basic characteristics of and differences between e-textbooks and i-textbooks. We discuss the properties of their building blocks, which should fully exploit their teaching potential in a high-quality i-textbook. In the case of the E-textbooks for science project, we present content-related and didactic guidelines, design trends and principles for the planning and production of i-textbooks. We focus on the concept and structure of each learning unit in an i-textbook. The I-textbooks created in this project are likely to shape the future of i-textbook production standards in Slovenian schooling. We therefore wish to shed light on the contribution of as many of the factors that influenced their creation as possible.

Key words: interactivity, textbook, e-textbook, i-textbook, production guidelines, learning unit, e-learning, blended learning

Introduction

The role and importance of information and communication technologies (ICT) has been rising inexorably in recent decades. The importance of these technologies has also been gaining momentum and value in the school environment (Mohorčič, 2012). Technology plays a key role in how students play, learn, obtain information and communicate with each other, so it is only natural for them to use various technologies in a learning environment (Geer and Sweeney, 2012). The constructivist approach, as a currently accepted paradigm of learning and teaching, is positively correlated with teachers and gives them a feeling of self-efficacy in integrating technology into a learning environment (Anderson, Groulx and Maninger, 2011). All school systems are trying to find the best way to implement ICT in the educational process from a teaching and learning point of view. The impact of technology on learning and teaching is different in various countries. Finland, Norway, Belgium and Korea have, based on findings by Aristovnik (2012) and taking into account the financial factors, PISA results, level of education, coverage of the Internet and the relationship student - teacher, the most favourable ratio. Slovenia, in most models, occupies a relatively favourable position in the second quartile. Although research results in this area are unclear, a hypothesis that computers will play a role of cognitive enhancers in future classrooms, is currently widely accepted (Lesgold, 2013).

Therefore, the importance of technology surely has an impact on the learning process, which can be seen in Slovenian schools (Batagelj, 1996; Zmazek and Šenveter, 2002). We can see a development of several didactic approaches that exploit the potential of this technology, but are not paying much attention to the technology itself (Kobal and Zmazek, 2007). At least three segments must be considered: education and training of childcare workers, teachers and principals, creation and concern for a proper e-learning environment and a supply of appropriate e-learning materials and e-books (Batagelj et al., 1998 Dinevski, Jakončič Faganel, Lokar and Žnidaršič, 2006 Zmazek, Hvala and Kobal, 2007). The first and second segment have been developed intensively as a part of the "E-šolstvo" (E-education) project, with financial support from the European Social Fund (ESF) and the Ministry of Education, Science and Sport (MZS), in which educators, teachers and principals systematically acquire digital skills. The field of e-learning materials has been developing due to numerous public calls for tenders made in the past by the Ministry, but the emphasis was never on the development of e-textbooks. That is why some learning materials followed the concept design of textbooks more, less, or not at all.

We would like to highlight "E-um gradiva" (E-um learning materials) (2006), which have been following the e-textbook design since the beginning of their development (Hvala, Kobal and Zmazek, 2007; Hvala, Kobal and Zmazek, 2008; Kobal et al., 2008; Zmazek etc., 2011 Zmazek et al., 2011b). Developers also followed some of the ICT didactic designs (Lipovec, Kobal and Repolusk, 2007; Kobal et al., 2007; Repolusk, 2009, Repolusk, 2013). The content quality of "E-um" learning materials is a result of strictly following techniques that implement didactic purposes (Pesek and Prnaver, 2008). Developers' tools are tailored to their requirements and often include authoring tools (Prnaver, Šenveter, Zmazek, 2007, Pesek and Regvat, 2007). These tools include thorough reviews and free publishing and enable a higher quality of e- learning materials (Pesek and Prnaver, 2008; Prnaver, Pesek and Zmazek, 2008). The authors of these materials have enriched their educational, didactic and technological pedagogical knowledge (Lipovec and Kosi Ulbl, 2008). The E-um web portal has also proved to be a useful source of knowledge for future primary school teachers, even though this was not its intention (Lipovec, 2009). Evaluation of the use of materials on the portal has shown that they have a positive impact on students' learning achievements (Lipovec and Kosi Ulbl, 2009).

Due to the increasing amount of pressure to develop e-learning materials, the "E-učbeniki za naravoslovne predmete" project (E-textbooks for science classes in primary schools) was developed. It is funded by the European Science Foundation and the Ministry of Education, Science and Sport, within which several substantive-didactic and technical-organizational guidelines were set and deployed, enabling logical continuation and an upgrade of base for development of e-textbooks (Zmazek et al., 2011 Kreuh, Kač and Mohorčič, 2011). The goal of the "E-učbeniki za naravoslovne predmete" project (E-textbooks for science classes in primary schools) is to develop e-textbooks with impeccable content and fresh didactic approaches, which are approved by the Council of Experts for General Education and will be used in primary and secondary schools as a replacement and an upgrade to printed textbooks. To achieve all these goals, e-textbooks must provide independent learning structures and comprehensive knowledge framework. Therefore, they must contain elements of knowledge acquisition, repetition, consolidation, verification and deepening of the knowledge gained.

In the following segment we will describe the development process of e-textbooks created in the framework of this project.

E-textbook or I-textbook

There is a growing trend of digitized traditional (printed) books that take advantage of the new media (Regulation on the approval of textbooks (2010) enables all forms of e-textbooks), which is why a new concept of **i-textbooks** (interactive e-textbooks) was introduced. This term describes e-textbooks that use new media to upgrade interaction with the user.

E-textbook combines content of a printed textbook and a workbook, but with **additional elements** that form a much more effective and stimulating learning environment. It enhances the power of insight and a deeper understanding of low, medium and high grade interactive elements (Repolusk and Zmazek, 2008);

- images, video, sound, animation, simulation (multimedia components), which are ranked low in level of interactivity;
- various tests (true/false, multiple-choice questions, gap-fill, etc.) ranked medium in level of interactivity;
- applets and educational game ranked high in level of interactivity (Figure 1).

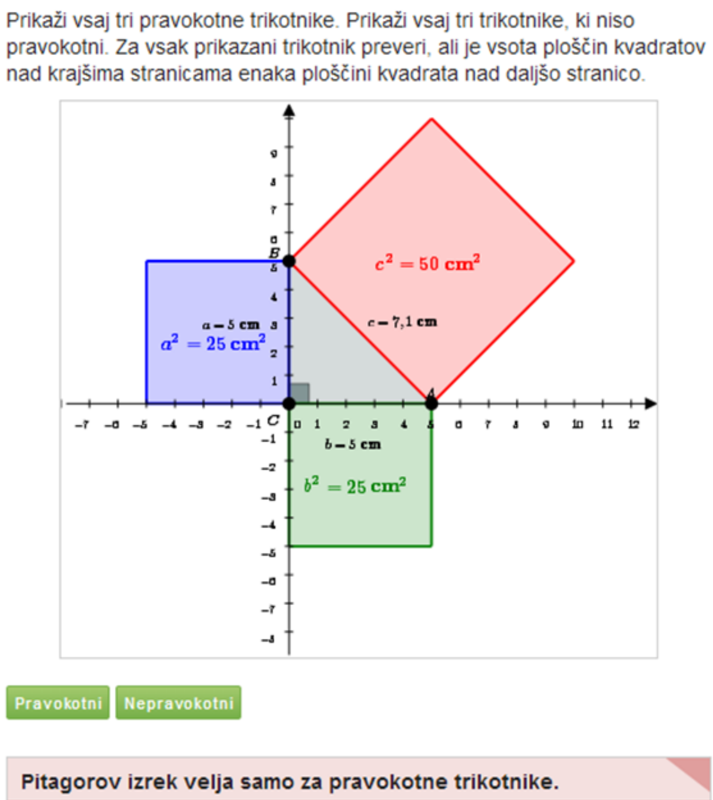

Figure 1: Applet for the Pythagorean theorem - element with a high degree of interactivity (source: http://eucbeniki.sio.si/test/iucbeniki/mat8/842/index3.html)

E-textbook covers the entire syllabus for each subject in a particular class with predetermined tags for each knowledge type. If the curriculum so defines, in addition to the general, specific and selective knowledge, then an e-textbook covers all knowledge types in the curriculum: mandatory, optional, general, specific and selective. Optional knowledge is marked by a red line on one side of the content.

A good i-textbook should meet the following substantive-didactic, technical-organizational and design minimum requirements: professional adequacy and correctness, methodical-didactic adequacy (general and subject specific), consistency with learning objectives and standards, achieving goals of the curriculum, feedback (real-time and non-real-time) with hints, taking into account a student's development phase, their skills and learning abilities, general didactic principles (gradualism, clarity, students' activities, etc.) especially the principle of multi-sensory learning by integrating appropriate didactic multimedia features, the ability to adapt to students with special needs, taking into account a student's cultural background, a unified exterior design and user identity, linguistic adequacy (emphasis on semantic, age appropriate state, communicative value of the information, understandable text and clear structure).

Development of e-textbooks includes, with public calls stipulated, use of existing e-learning materials (or parts of) developed under the auspices of the Ministry and co-funded by the European Social Fund in the years 2006 to 2011 (Videofon, 2006; E-um, 2006; Nauk, 2008; E-vadnica za fiziko, 2008, etc.). The E-um web portal has shown to be a great starting point for development of textbooks for Mathematics, Physics and Chemistry.

E-learning unit, base of an i-textbook

I-textbook has an index structured content covering each learning set that contains learning units with meaningful content covering one and up to three teaching lessons. Development of an i-textbook included an incorporated targeted approach, with a pre-formatted index table, which included the objectives of the curriculum (Figure 2).

E-learning units are not theoretical didactic preparations for a teacher, but a stimulating, friendly and productive environment for independent teaching, which encourages development of relational learning (Skemp, 1978), associated with the construction of cognitive schemata with a strong emphasis on comprehension as an essential component of conceptual knowledge (Hiebert, 1986). That is why e-learning units form a specific network (Figure 3). The definition of key ideas forms a basis for profound knowledge of mathematics (Ma, 1999), which is why a directed network of e-learning units connects a selected e-learning unit with other key e-learning units, contents which are necessary for the understanding and acquisition of new skills, implemented in a selected e-learning unit.

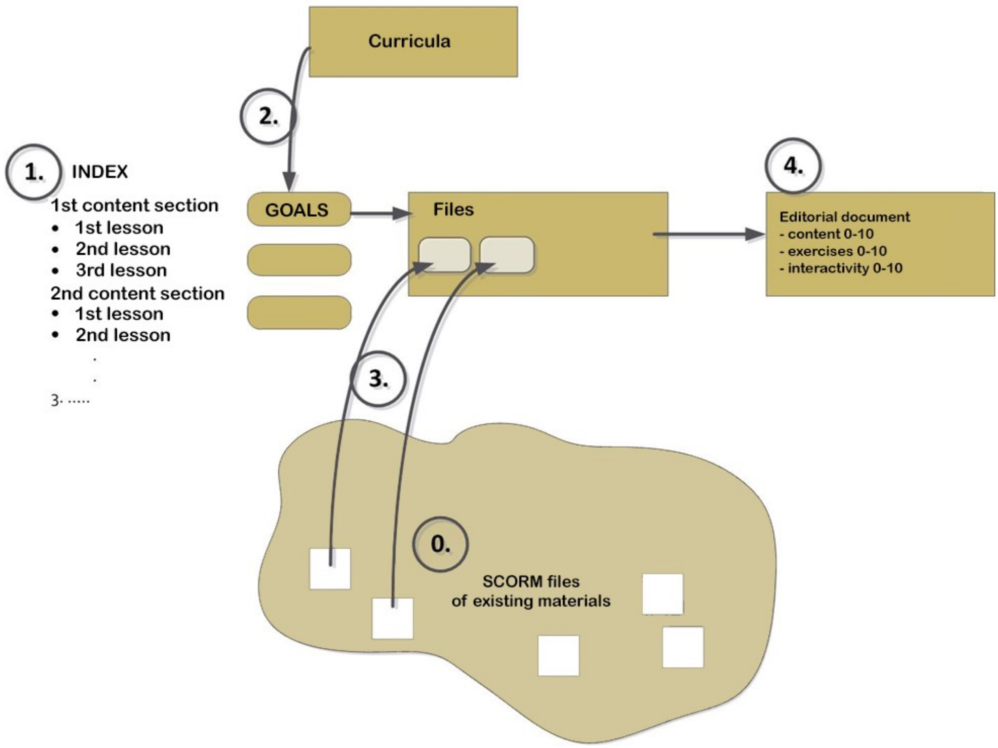

Figure 2: Integration of i-textbook content with the objectives of the curriculum

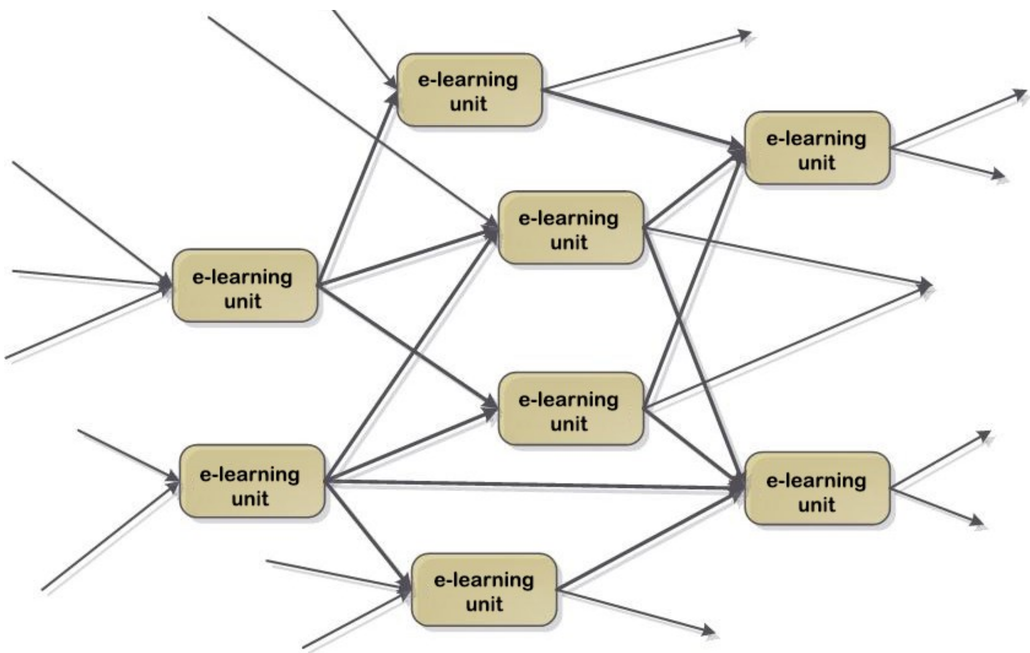

Figure 3: A directed network of e-learning units

E-learning units encourage active self-learning, which is optimally achieved by solving problems with reactive cooperation instead of passive reading (Repolusk and Hvala, 2008). That is why they must offer a sufficient amount of interactive and dynamic elements provided by the modern technology (graphics, audio sequences, video projections, animations, slides simulations and applets). They also include drawings with a high level of educational usability that introduce the essence of a problem, which enables understanding or provides a solution to a problem. A hyperlink is not considered as an interactive element.

Modern interactive and dynamic elements can play a constructive as well as a destructive role in the learning process. They can be a useful tool in ensuring active participation of a student, with a better presentation of the facts and a deeper understanding of the material. Misused elements can cause student to lose focus of the essential objective. Dynamism and interactivity therefore should not be only a means by itself. They must be used to achieve constructive goals (Zmazek, Kobal, and Zmazek and Hvala, 2007).

Structure of an e-learning unit

The content and structure of e-learning units must be adapted to a specific subject area and specific content that the e-learning unit covers. A sequence of substantive elements of an e-learning unit should not be considered rigidly. It can always be adjusted due to different didactic approaches and forms of effectiveness.

The proposed sequence of content elements is as follows (Figure 7):

A. A TITLE should be as short as possible; Subsequent sub-headings are possible, but should not be too frequent and should only be used as separation of major topics of e-learning units.
B. INTRODUCTION:
    a. Motivation or contextualisation, which either specifies a particular challenge (problem), to which we will be able to apply new knowledge, or integration of a new content.
    b. Motivation can be followed by identification of prior knowledge, usually with high interactive tasks. This applies to situations when a user requires a level of prior knowledge that exceeds the knowledge of previous e-learning units of the same learning set or if a user is younger. In this case, a brief summary is offered to the user trough identification questions. This summary has a technical design and includes hidden text elements so that the learning material is not extended and therefore does not lose its central role.
    c. Each learning unit must include a short presentation of the content. If the tile of a unit is "x", then an introduction "We will learn about X" is

definitely not acceptable. Introduction must include a short summary of "where we come from and where we are going" (Figure 4).

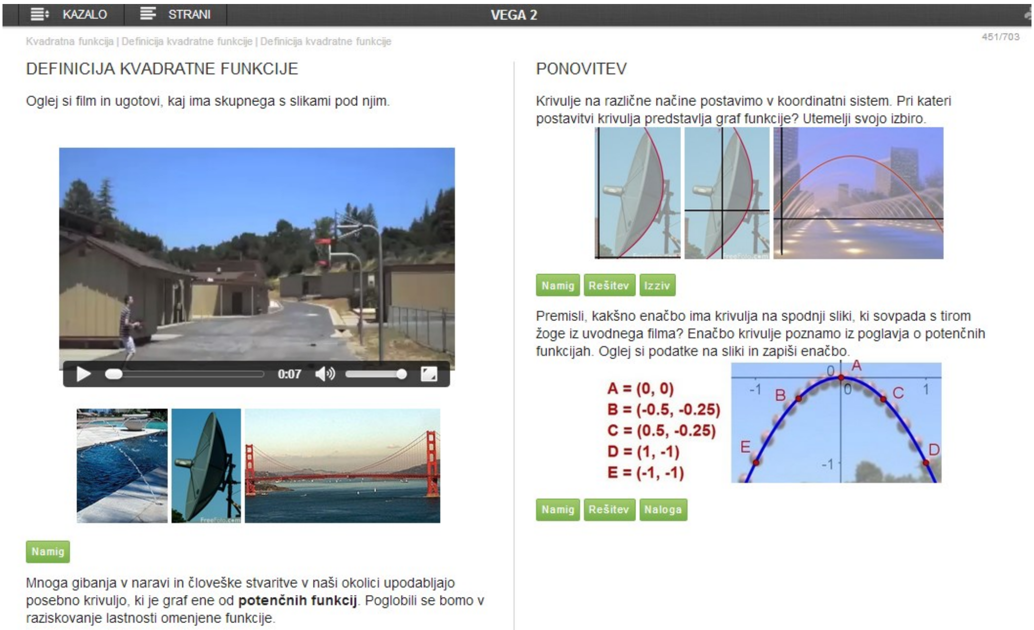

Figure 4: Example of an introduction page (Vega 2 i-textbook) (Source: http://eucbeniki.sio.si/test/iucbeniki/vega2/278/index.html)

C. Introductory elements of e-learning units are followed by its central part, A BODY, through which new subject-specific knowledge is acquired. The body provides users:
    a. with new knowledge of TERMS (objects, events, laws, etc.) trough inductive activities,
    b. PROCESS KNOWLEDGE (cognitive skills and competences),
    c. ACTIVITIES to gain new skills and competences and
    d. EXAMPLE EXERCISES to consolidate and review learned content and goals.

The above described content elements of a body are not set in any specific order, but are dependent on substantive and educational goals. We must take special care to test students and their new acquired knowledge (between substantive elements of the body) and in the case of a misunderstanding direct the user back to the text or offer further explanation (in a different way, for example with contextualization). The design of a body must make use of computer technologies to full extent, especially as a medium that enables content and learning path differentiation, which guides the user from one element to another. General, specific or selective knowledge of the curriculum, especially terms and process knowledge, is marked by pre-specified marks as shown in Figure 5.

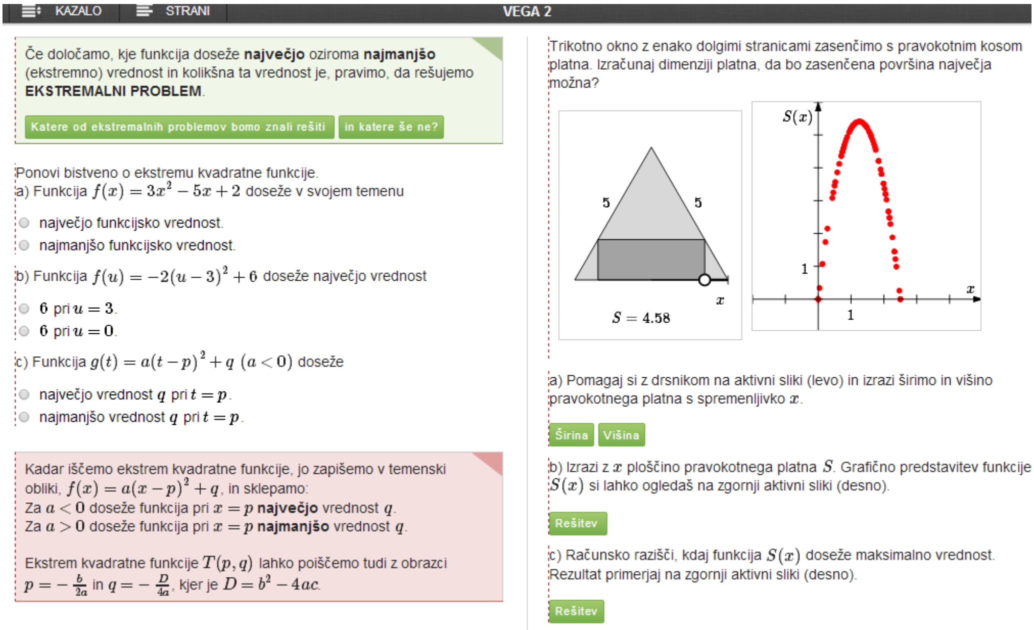

Figure 5: Example of special knowledge (i-textbook Vega 2 – solving external problems (Source: http://eucbeniki.sio.si/test/iucbeniki/vega2/286/index2.html)

D. **CONCLUSION** of an e-learning unit contains:

a. an **answer** to the initial challenge or problem, if one was introduced,

b. a **summary** of what we have learned. For longer or more complex e-learning units or for e-learning units intended for a lower age group, short summaries can be provided in the body, but the final summary still sums up all that we have learned trough this e-learning unit (Figure 6),

c. a **set of exercises** - exercises at the minimum level of standards of knowledge, exercises to verify achievement of standards of knowledge and exercises for broadening and deepening of knowledge.

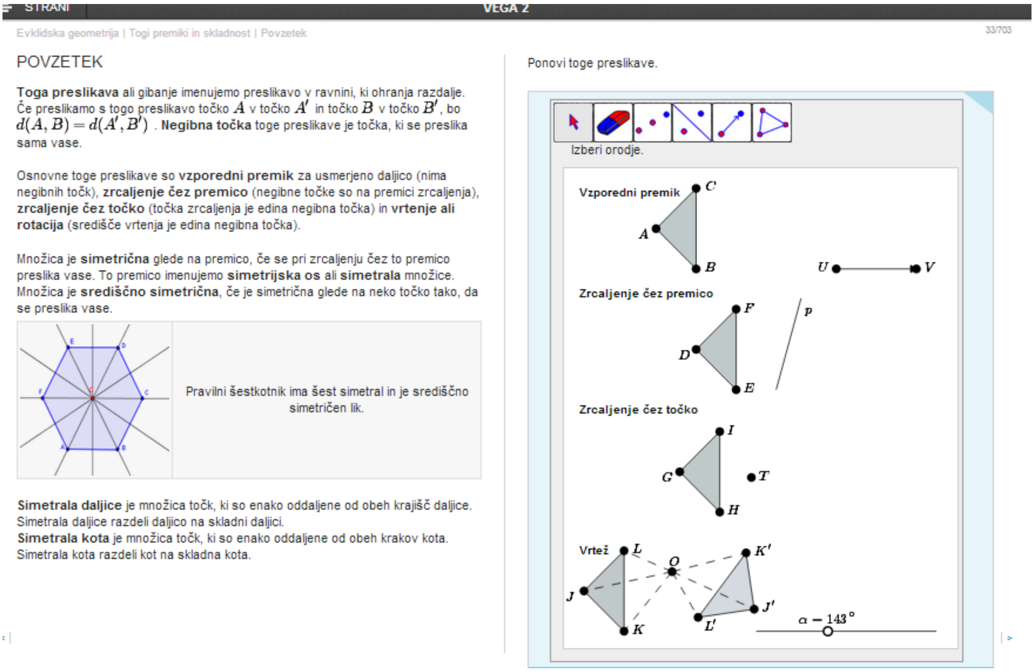

Figure 6: Example of an introduction page (Vega 2 i-textbook) (Source: http://eucbeniki.sio.si/test/iucbeniki/vega2/230/index8.html)

Multiple exercises of an e-learning unit cover all taxonomic levels and all types of knowledge. Specific pre-specified marks denote problem-based exercises or exercises that can be solved with computer tools outside i-textbook. Some of these tools include: Excel, Geogebra (2001), GeoNext (2002), R.i.š (2001), Euler (Batagelj and Zaveršnik, 1998), JSXGraph (2008), JMol (2002), JSMol (2002). The list shows that these tools adjust to the development of technology. Each subject group decides in advance what classification of exercises would be most appropriate and, in accordance with the present curriculum, appropriately named or labelled.

E. SOURCES

Each learning unit must include **a list of sources used**; that is if we drew content from existing sources. We must also recommend **resources for further deepening of knowledge**, exceeding the objectives set out in the curriculum. We can also alert the user of a possibility of cross-curricular integration of content. We pay particular attention to the curricula already offering some cross-curricular integration.

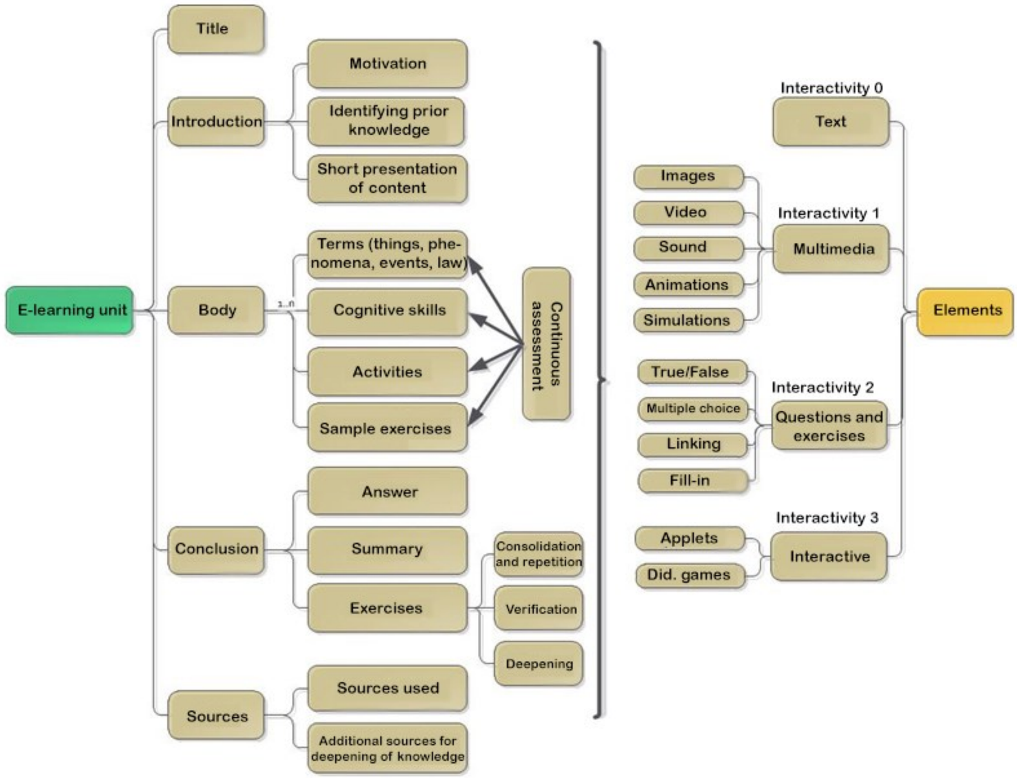

Figure 7: Suggested structure of an e-learning unit

I-textbook structure

E-learning unit representing completion of a unit as a whole (1 to 3 hours of school work), must take advantage of the computer as a medium and express a correct relationship between the content and other interactive elements. For each 1000 characters of text (800 or less on a lower level of education) a learning unit must include at least 1 interactive element (more is better) of at least medium level of interactivity. An e-learning unit must contain from 2000 (for one hour of school work) to 6000 characters of text (for three hours of school work), and as a rule, an appropriate number of interactive elements (from 2 to at least 6). E-learning units designed for three hours of school work should be avoided and used only when the content cannot be divided into several e-learning units.

The content of an e-learning unit should be displayed as a full screen sequence of images, so creators and editors must ensure a sensible distribution of elements in order to avoid empty or overcrowded images.

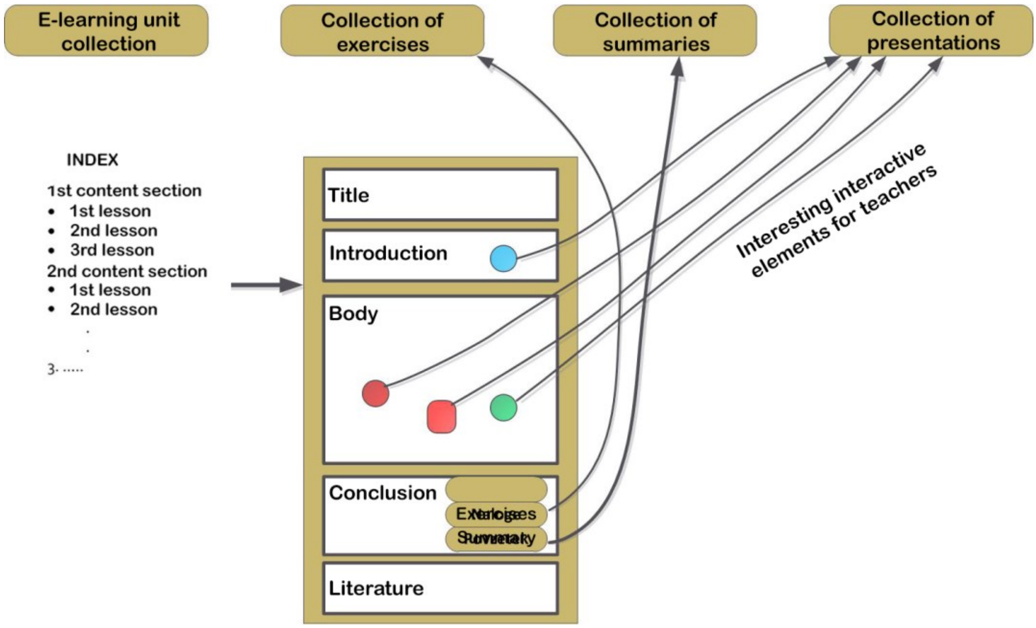

Figure 8: I-textbook structure

An I-textbook is actually A COLLECTION of e-learning units and other elements. We can manufacture following collections extracted from all e-learning units (Figure 8):

– A COLLECTION OF EXERCISES: sets of large quantities of exercises in the conclusions of e-learning units,

– A COLLECTION OF PRESENTATIONS: interesting images, videos, sound elements, animations, simulations, learning games and applets,

– A COLLECTION OF SUMMARIES: end summaries.

A subject's curriculum based INDEX TREE forms a base for an i-textbook, which may include class year, but must include content sets of an e-learning unit. A tree structure provides a clear link with the curriculum (subject catalogue) and makes it easier to switch between different collections of i-textbooks (collection of e-learning units, collection of exercises, collection of presentations, and collection of summaries).

General guidelines for e-learning unit content:

Even though a teacher will be able to use certain parts of an e-learning unit, it is in its entirety **designed to encourage individual work**. It should therefore be designed to lead a user throughout the whole unit. It must be unambiguous, motivational, encourage curiosity and creativity and should enable clear understanding of its contents. It should also encourage activities like reading, writing, designing, troubleshooting, research, cooperation, etc. and ensure feedback. E-learning units are not by any means theoretical didactic preparations for a teacher, but a stimulating and productive environment for learning. That is why hyperlinks must be avoided, except at the end of a unit, where we can cite and link literature for broadening and deepening of knowledge. This is one of the ways to ensure that students focus on the unit and do not lose themselves on the Internet, where one click quickly leads to another.

Tips for designing i-textbook content for mathematics and science

These are guidelines posted for the "E-učbeniki za naravoslovne predmete" (E-textbooks for science classes) project on the administrative portal (Zmazek et al., 2011a):

1. *Compliance with the curriculum*. All goals determined by the curriculum, on a certain level of education, must be included in an i-textbook. It must also include meaningful and progressive introduction of new concepts and skills. The author must have knowledge of development of concepts and skills, which is crucial for the construction of a good didactic approach (Clements and Sarama, 2004). That is why a curriculum is a document that is used regularly, paying particular attention to the didactic recommendations and the accompanying sources. E-learning units must be professionally sound (e.g., it is not permitted to use derivatives of terms, which may be used when in a classroom, but are not appropriate for textbooks (specific fractions, aspirin formula, etc.)). We must use established and pre-agreed terminology. We should use a modern approach in units, but not at the expense of professional integrity. Good pedagogical content knowledge is a fundamental component of good teaching and hence learning (Ball, Thames and Phelps, 2008).
2. *An editor determines the sequence of materials.* The sequence of materials is sometimes in conflict with authors practice, but an author must follow commentary and index tree set by an editor to provide meaningful coverage of the whole unit. An editor can modify the order of content only in agreement with the authors, when there is reasonable ground for improvement.

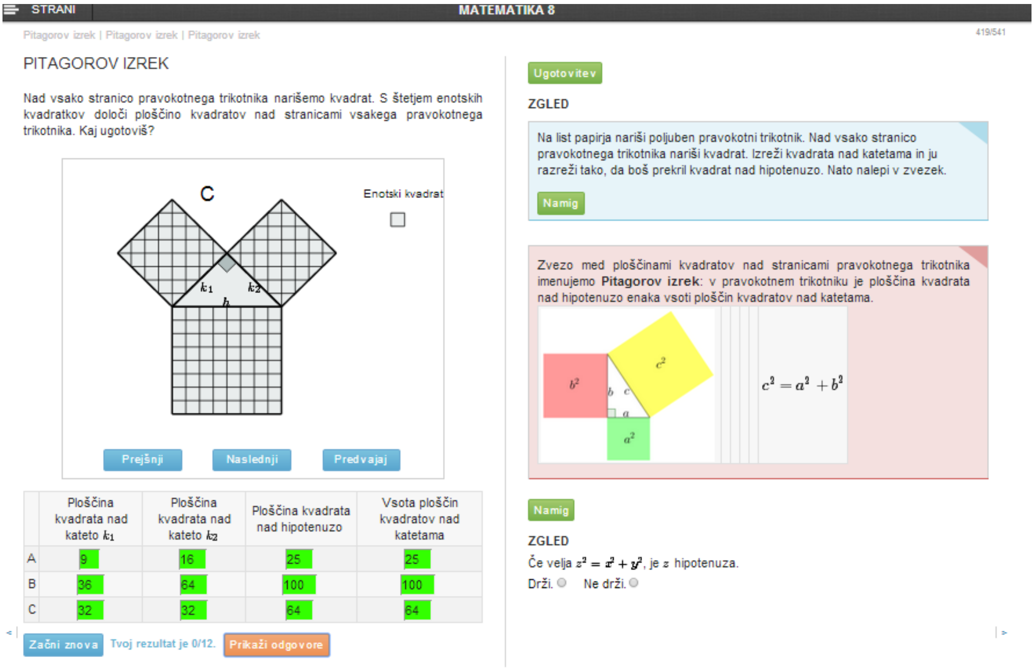

Figure 9: An inductive approach to the introduction of the Pythagorean theorem (i-textbook - Mathematics 8) (Source: http://eucbeniki.sio.si/test/iucbeniki/mat8/842/index2.html)

3. *Inductive approach to the development of a new term.* Whenever possible, we must take advantage of an i-textbook and its features (interactivity) for the acquisition of new concepts; with successive reflections and user guidance. A formal definition of a term should, if possible, follow the already-verified intuitive understanding of already introduced concepts (Resnick, 1989). We must avoid terms like definition, theorem, proof, and rather use sentences like Let us agree, justify, etc.

    a. A fluent transition between different representations (Bruner, 1967) characterizes the knowledge of understanding, which is why new terms should be presented in several different ways and with multiple representations (e.g., an increasing function presented with a graph and table, etc.).

    b. New concepts and principles cannot be introduced with concepts and devices that are even less known to the user than the content itself (e.g., combinatorics and probability theory with card games, which may not be well known to everyone, addition and subtraction cannot be introduced with the concept of positive and negative tokens, which can be difficult to understand to someone unfamiliar with the concept, etc.).

4. *Language style and amount of text.* An I-textbook should not be written in an explanatory manner, it should rather encourage activity. Reading should not be the dominant activity. The amount of text can be increased with the age of students, but the unit must maintain fluency. We should avoid unnecessarily long text that may serve as a motivational story in class, but in a textbook it may inadvertently become a distraction for students.

    a. We should pay special attention to the clarity and relevance of the text, especially in primary school. Use words that a user will understand (e.g., we do not ask a fourth grader what was the amount of overnight accommodations in a hotel, we ask him how many people slept in a hotel), form short sentences, use less pronouns, etc.

    b. We make sure we do not use analytical and geometrical representations of a term interchangeably (e.g., an increasing function is a result of the increment value of the independent variable, but it is not the coefficient of a straight line in a linear function). Language style should, especially with geometric content, reflect the Van Hiele's model (Van Hiel, 1984).

5. *Interactive elements.* E-learning units must include an adequate amount of interactive, dynamic and other elements provided by the modern technology.

6. *Use of notebook, planning, notes.* Users require specific and correct instructions on what to do (e.g., with a ruler and a pair of compasses construct, try to fold a sheet of paper according to the instructions in the drawing, with tools for dynamic geometry construct, arrange data using computer spreadsheets, etc.). Instructions are also given outside of the frame of an i-textbook unit, many times a user is instructed to use materials or ICT tools outside the unit. This enables effective learning for different types of students, strengthens their competences in the use of ICT tools and ultimately realizes the objectives of the curriculum.

7. *Exercises*

    a. Instructions for exercises use different verbs (e.g., from Bloom's taxonomy; Anderson, Krathwohl and Bloom, 2001) that allow control over the taxonomic diversity. However instructions cannot start only with verbs like calculate or solve but also with arrange, justify, evaluate, use, etc.

    b. We divide exercises into three levels of difficulty, where we must be careful not to only use exercises of retrieving facts and procedures for the lowest level of difficulty, but also conceptually based exercises (Figure 10). This enables level transitioning. We also do not use similar exercise types for higher levels of difficulty (e.g., exercises structured for a higher level of complexity in high school, like matura exercises). E-learning units must contain a sufficient amount of challenging problems. A problem-solving approach is necessary in mathematics and science subjects (Schoenfeld, 1985), determined by the curriculum and used too sparingly in existing textbooks and other materials.

c. For multiple-choice type exercises we must carefully choose which distractors we use, to determine why, when and if a user gave a wrong answer. We can also add comment to a wrong response to help user expand his understanding of the content.

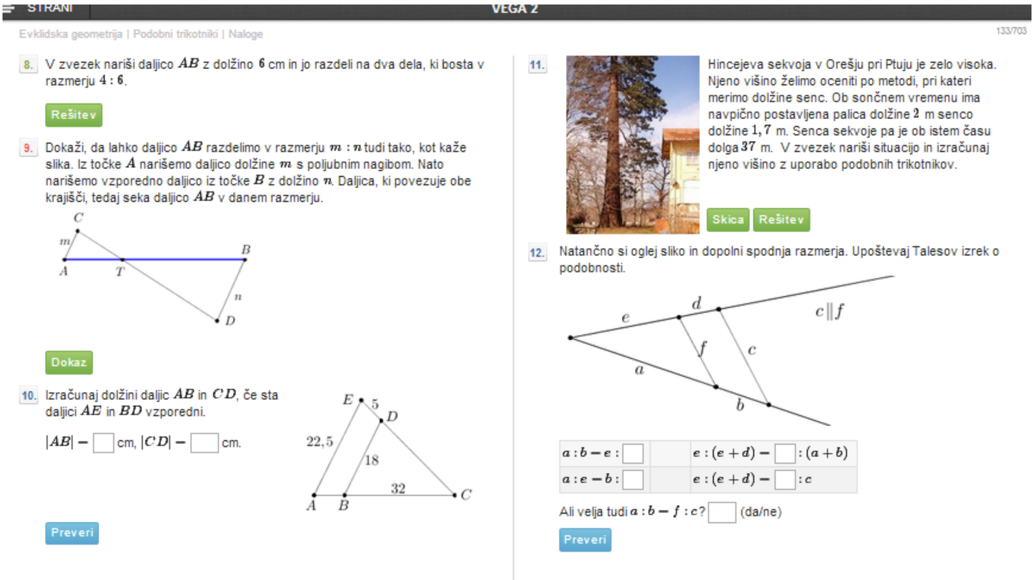

Figure 10: Exercise difficulty levels (i-textbook Vega 2) (Source: http://eucbeniki.sio.si/test/iucbeniki/vega2/243/index6.html)

8. *A summary.* A summary includes a short and entertaining presentation of e-learning unit content. We can use a motivational applet or any other applet that helps motivate a user and display content. We must bear in mind that summaries will form a collection, which is why the content must be an independent unit functioning on its own.

9. *Cultural and historical placement of content.* Introduction and body of the unit must illuminate, as much as possible, the cultural and historical perspective of the content. Historical achievements and mathematical giants must be presented as an interesting fact. They are usually written under in the content of interactive buttons.

Conclusion

ICT is a part of modern life. It provides us with an instant access to information, materials and services and provides a new opportunity for equality in education.

We present the basic concepts that have led to a design of i-textbooks created in the framework of the "E-učbeniki za naravoslovne predmete" (E-textbooks for science subjects) project. Textbooks have been presented to the general public only in their rough form (Lipovec et al., 2013) as they are still in development. The structure and didactic guidelines of i-textbooks are based on the knowledge of many subject-specific didactics and didactics of technology use in teaching. The development of textbooks is based on scientifically validated knowledge (Repolusk, 2013), intertwined with personal experience of seasoned teachers and enriched with technical support based on substantive-didactic requirements. This paper highlights the role of higher level of interactivity and differentiates e-textbooks from i-textbooks. We believe that i-textbooks will contribute to the deepening of knowledge and we hope we set an example of good practice in ICT driven didactics, which is still developing in Slovenia.

We want to re-emphasise that modern interactive and dynamic elements can play a constructive or a destructive role in the learning process. They can be a useful tool in ensuring active participation of a student, with a better presentation of the facts and a deeper understanding of the material. Misused elements can cause a student to loose focus of the essential objective. Dynamism and interactivity should therefore not only be a means by itself (Zmazek, Kobal and Zmazek, 2007).

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Technical and organizational guidelines in the production of i-textbooks

Igor Pesek, Blaž Zmazek

Amendments to the Rules of Validation of textbooks in the Republic Slovenia from 2010, which also included the validation of e-textbooks, did not take into account the guidelines for producing e-textbooks established at that time. Consequently, all e-textbooks had to be validated, including digitized printed editions, which include no interactive elements, and, therefore, do not exploit the benefits of digital media. The term e-materials and e-textbooks covers the wide range of various forms of electronic materials, including all digitized materials, multimedia materials and interactive textbooks; therefore, it is crucial that the technical and organizational guidelines be prepared before the start of actual i-textbook production. In this paper, we give a detailed description of each segment of the technical and organizational guidelines for e-material preparation.

Key words: interactivity, textbook, e-textbook, interactive textbook, learning unit, guidelines

Introduction

It may seem as if interactivity in educational content is something that has been developing only in the recent years. First examples of software solutions in programme languages (Java, JavaScript, etc.) in Slovenia were used in HTML in mid nineties (Batagelj , 1996; Batagelj and Zaveršnik, 1998, Batagelj, 1999), shortly after the beginning of the World Wide Web in 1992. With the development of Internet browsers a doorway opened to online publication of educational content.

Technological development in the field of computer hardware has in the following years enabled an effective use of interactive content, especially in Java programming language, which experienced the biggest boom in this period: R.i.š. (2001), GeoGebra (2001), GeoNext (2002), JMol (2002). These programmes for dynamic geometry and 3D presentations of chemical molecules enabled integration of applets into a web page with educational content (Zmazek and Šenveter, 2002).

Since 2006, the Ministry of Education and Sport of the Republic of Slovenia announced several tenders for development of e-learning materials for use in classrooms as a part of the curriculum in primary and secondary schools. Projects were mainly supported by the European Social Fund and partly by the Ministry of Education and Sport. Several e-learning materials were created in these projects (E-um, 2006, VideoFon, 2006, Nauk, 2008, E-vadnica za fiziko, 2008), which were based mostly on HTML, Java and Flash. Due to security restrictions on some newer operating systems (e.g., iOS), their functioning soon became difficult or even impossible.

In January 2010, when Apple introduced the first version of the iPad tablet computer, which does not support web site integrated Java and Flash applets, it was clear that we must focus on content independent of these programs. Choosing HTML5 as the standard markup language has proven to be a well-founded choice. The widespread use of smart phones has almost unified the user experience with tablet computers. Experience has shown that JavaScript is the most appropriate programming language for development of interactive elements for web content. Research groups have developed different JS-libraries (JSXGraph, 2008 JSMol, 2010) for specific areas of expertise.

The technical-organizational baselines for e-materials and e-textbooks had to be adapted to the technological changes in the last two decades of the online educational content development. First basic records can be found in the MIRK project (Batagelj, 1999), followed by a document for evaluation of e-learning materials developed in the framework of e-learning projects since 2006 (Batagelj et al., 2005), and later an assessment model for e-learning materials (Dinevski, Jakončič Faganel, Lokar and Žnidaršič, 2006). The "E-um group" developed a more complex design and axiomatics for e-materials and the e-learning vision. They have been developing mathematic e-learning materials for the entire vertical of primary and secondary school education since 2006 (Hvala, Kobal and Zmazek, 2007; Kobal, Hvala, Zmazek, Šenveter and Zmazek 2007; Lipovec, Kobal and Repolusk 2007; Zmazek, Kobal and Zmazek 2007; Zmazek, Kobal, Zmazek and Hvala 2007; Kobal and Zmazek 2007). Rules of procedure and a quality management system have been introduced in the context of implementation of this extensive project (Zmazek, Hvala and Kobal, 2007), which describes all processes in the implementation phase of this project. The most important support mechanisms in the "E-um project" were authoring tools (Pesek and Regvat 2007), automatic accompaniment (reviews, proofreading, technical support, etc.) and publication of e-learning materials (Prnaver, Šenveter and Zmazek 2007; Prnaver, Pesek and Zmazek 2007; Prnaver, Pesek and Zmazek, 2008). An important part of e-learning materials publication is monitoring user feedback and an appropriate response to comments, suggestions and questions (Hvala, Kobal and Zmazek, 2008). A precise definition of the concept of an e-textbook (Zmazek et al., 2011) was made based on feedback of users, authors and editorial team of the "E-um" project (Kobal, Hvala, Zmazek, Šenveter and Zmazek 2008; Pesek and Prnaver 2008) as well as previous experience with the use of interactive elements developed in the framework of the "E-um" project (Repolusk and Hvala 2008; Repolusk and Zmazek 2008).

An overview of international results for the development and use of e-learning materials has been carried out and presented in the master's thesis by Repolusk (2009). In September 2011, based on the recommendations for the development of e-textbooks (Zmazek et al., 2011) and as a result of good practices in projects developing e-learning materials, the National Education Institute of The Republic of Slovenia released a publication titled "Izhodišča za izdelavo e-učbenikov" (Baselines for the Preparation of Electronic Textbooks) (Kreuh, Kač and Mohorčič, 2011), which should lead to a greater consistency in the preparation and validation of e-textbooks in Slovenian schools. Unfortunately, amendments to the Guidelines for approval of textbooks in 2010, which included certification of e-textbooks, did not take prepared guidelines into account and allowed a validation of all digitized printed books (in pdf format), which do not directly contain interactive elements and therefore do not take advantage of the digital media. The concept of e-learning materials and e-textbooks contains a wide variety of different forms of electronic materials, including all digitized, interactive and AV rich e-textbooks, which is why special technical and organizational guidelines were made for the development of interactive textbooks in the "E-textbooks for science classes in primary schools" project (project implemented by the National Education Institute and financially supported partly by the European Social Fund and the Ministry of Education, Science and Sport).

Technical guidelines for the development of textbooks

The guidelines were prepared and presented to the "E-učbeniki za naravoslovne predmete" (E-textbooks for science classes in primary schools) project management and editorial team in December 2011. They were approved and include the following key factors:

– i-textbooks will be used on different devices, but personal computers and tablets are the primary target group;

– the screen resolution restriction is set to 1050 px (width) x 700 px (height);

– i-textbooks will be used and displayed on specially developed applications for the most common operating systems: Microsoft Windows, Apple iOS and Android;

– content will be placed on a local device, which is why long access time and loading of content is not planned;

– tablets will be used in landscape and portrait mode.

The implementation of interactive materials:

– must take into account the expected development of platforms in the future;

– must provide the option to modify the content of the i-textbook;

– individual learning units must include metadata for placement into the curriculum;

– learning units must consist of basic elements (text, audio and video content, interactive elements, etc.).

I-textbook for a specific subject must include: index tree (server or user updated), curriculum and/or catalogue, textbook, collection of exercises, collection of activities (applets, lab exercises, etc.) and an exam generator.

Guidelines for the use and development of interactive textbooks and e-learning units

Guidelines for use of interactive textbooks consist of four levels: collection of e-textbooks, e-textbook, content set, learning unit. The method for the use of i-textbooks is, at a higher level, designed for the development of dedicated application of i-textbooks use. However, the design of e-learning unit levels must take into account that:

– the most frequent use of i-textbooks is on this level;

– landscape is the most frequently used display mode;

– the content of learning unit consists of introduction, body, summary and exercises;

– in landscape mode the content will be arranged into two columns, exceptionally one, if the interactive element is too wide for a single column and very rarely in three columns (short exercises);

- simple page scrolling must be enabled (forward and back), transition between content sets must be clear (previous page, when a user is on the first page of a learning unit; next page, when a user is on the last page of the learning unit);
- portrait mode simulates infinite learning unit page, only one page is displayed;
- simple page scrolling must be enabled for the portrait mode as well;
- thumbnails of images and interactive elements should be placed at the edge, only important elements stay in their original size or all elements remain in their original size, if author so desires;
- in portrait mode a page consists of two imaginary columns: a wide central column and a narrow columns for thumbnails or text; thumbnails are linked to a dedicated interactive element or their original image size;
- the content of e-textbooks will be divided according to its level of complexity (general, specific and optional knowledge) and appropriately marked (e.g., text highlight colour).

To ensure integrity and unity of i-textbooks, a specific set of guidelines for the structure of e-learning units had to be prepared and followed. The guidelines had to meet technical requirements for the preparation of interactive textbooks and to ensure their viability. I-textbooks are designed by teachers that are experts in their respective subject area and have a good understanding of meaningful use of interactive elements in i-textbooks, but they may not necessarily be computer experts (computer scientists help authors develop complex interactive elements according to clear scenarios and technical capabilities of interactive element tools).

The following is a detailed description of individual segments of baselines for the development of e-learning units. Author's tool eXeCute is, among other things, used for ease of record. Let us emphasize that interactivity is a fundamental objective of a modern i-textbook, which is why guidelines must encourage authors to strive for higher levels of interactivity, i.e. multiple recursive loops in communication with students, to encourage self-learning and metacognition. According to the definition of the level of interactivity, we classify the control of audio and video player as a low-level activity. Medium level of interactivity provides feedback, which depends on a students answer. High level of interactivity provides multiple interactions between a user and the system.

Guidelines:

1. Range of elements in an e-learning unit: 1 e-learning unit includes content for 1 to 3 hours of school work.

a. A basic e-learning unit (1 hour of school work) comprises on average from 3 to 4 pages of eXeCute. 1 e-learning unit comprises of 5, 7 or 9 pages (for 1, 2 or 3 hours of school work):

   - Introduction: 1 page (always 1, unless it is the beginning of the e-learning chapter then 2);
   - Body: 1 page and 1 additional for each basic e-learning unit;
   - Summary: 1 page (always);
   - Exercises: 1 page for each basic e-learning unit (more exercises, if body content is short; for 1 basic e-learning unit there must always be at least 3 body pages with exercises).

b. One eXeCute page contains at least

   - 1 multimedia element
   - 1 interactive element, except an Exercise page (exercises with solutions), where multimedia and interactive elements are not necessary.

c. 1 basic e-learning unit contains at least 1 high level interactive element (at least medium level, if it can be justified), 1 e-learning unit contains at least 1 high level interactive element.

Structure of an e-learning unit

a. An e-learning unit consists of individual pages. The pages are displayed in two columns, except when larger elements are used; then we use only 1 column, and 3 columns for Exercise pages with short exercises.

b. Each page has its own title displayed in the index tree on the left side and in the page preview as page heading. The page title will enable the user to quickly find the desired content. One title can be set for several consecutive pages (e.g., we do not use numbering Exercises 1, Exercises 2, but Exercises). If a page contains another title, the title of the page remains the same as the first title. If a page contains no title, the title of the page is the same as the title in a previous page.

c. Type of page (Introduction, Body, Summary, Exercises or Sources) must be consistently labelled.

d. Root page (only one in a unit) is set for the Introduction.

e. Next e-learning section contains Body pages. The body generally does not include generated exercises. Body exercises are generally not included in the Collection of exercises. It contains solved unnumbered examples and exercises titled Examples.

f. Summary page must be appropriately marked and must immediately follow body section. If the summary does not cover the entire page, we must fill the page appropriately.

g. Exercises are written in pages after the summary section. Page layout is set to two columns. Each exercise must be positioned into its own element. Exercises are automatically numbered. Solutions are written under buttons.

h. Source page contains information on images and other material that was used in the e-learning unit. It does not fall within the expected norm scale and design of an e-learning unit.

Metadata and element tags:

a. Each unit must contain at least 3 keywords (intended for user browser content).

b. Elements must include level of content tags (general/mandatory, special, optional knowledge). Default content level is general/mandatory knowledge.

c. Each exercise (element) must include tags for exercise difficulty (at least 3 levels):

   – 2 (minimal standard)

   – 3, 4

   – 5

   Caution: This is a rough simplification of various taxonomies and is intended only for internal use as a basis for classification of exercises. We must also stress that exercises at lower levels are not merely of procedural type or recall of concepts and facts. Problem exercises are also not only of the highest difficulty. High school special knowledge exercises are not constructed as in matura. Structured exercises are also made for general knowledge.

d. Elements must have a selected format (text, an important fact, a definition, an interesting fact, an activity, collection of activities). An applet or any other activity can be selected as an Activity in the drop down menu, if we do not want it included in a collection (for teachers). The eXeCute drop down menu also contains a "Put in a collection" option.

Content design:

a. Content must fill an entire page; a page must not contain any large empty spaces.

b. A page should not contain two active animations as they can be distracting. A page can contain two applets or more if they are controlled by the user.

c. All graphs should use "a circle" for points.

d. Maximum width and height of applets, pictures, video, etc. should be 450 px. If that is impossible, then the maximum size can be set to 800 x 500 px (but must be followed by a one column page layout).

   Image resolution must be lowered to 1280 x 800 px.

e. Pictures and videos standing alone in a row have to be centred.

f. Videos must be converted to a WebM format (or Ogg).

g. Each Java applet element has to have a video or a gif animation presentation of the applet (for user platforms that do not support Java, e.g., iPad) and a representative picture (about 450 x 450 px) of the applet (for textbook printing).

h. All mathematical symbols, variables, functions, etc., are written in LaTeX (between $ $ or $$ $$ or $\displaystyle{ }$). We must be careful not to write formulas as images.

i. We must use pre-agreed mathematical codes for numeral systems, vectors, etc.:

   – Arithmetic operations: we use +, - , :, and not ÷ or ×. There are no spaces before or after arithmetic operations. [Algebraic expressions are written in LaTeX.]

   – Units of measurement: we write them together with numbers in LaTeX in \rm with a "hard" space (\,). e.g., $15\, {\rm kg}$.

   – Function names: we write them in LaTeX and use built-in functions (\tan, \cot, \arctan, etc.). For functions, which have no definition in LaTeX we use this template: we write arccot (x) as ${\rm arccot}\, (x)$.

   – Sets: we write them in LaTeX like this: \mathcal e.g., $\mathcal{A}$.

   – Big numbers are written with the shortest space possible in LaTeX, e.g., 1000000 as $1 \, 000 \, 000$.

   – Decimal mark: we use decimal notation of numbers with a decimal comma: e.g., 23 456,98 [We write numbers in LaTeX, add space for large numbers, e.g., $23 \, 456,98$].

Conclusion

This project, on the basis of technical and organizational guidelines, has enabled in a very short period of time the development of several high-quality i-textbooks for mathematics and science subjects in primary and secondary school, which have been confirmed by the Council of Experts for General Education of RS. Because these guidelines are designed to adapt to any technological changes in hardware and software, we believe they will be a good basis for the development of i-textbooks in other subject areas.

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Technical and administrative supporting mechanisms

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Technical and administrative support mechanisms, the technical support team of the E-textbooks project, is one of the project's cornerstones. It has had several functions: overseeing the development of tools and environments for other project participants involved in creating i-textbooks, implementing the technically advanced interactive elements of e-learning units, performing technical processing of inadequate elements, and conducting other administrative and technical support. The article presents the tools, the environments and the mechanisms by which all this was done.

Key words: technical support, authoring tools, administrative portal, reviewing process

Introduction

The project of i-textbook development in the scope and objectives of the project "E-učbeniki pri naravoslovnih predmetih v osnovni šoli" (E-textbooks for science classes in primary school, referred to in short as "E-books") was a complex task. A view of the project in its completion confirms the assumption made at the beginning of the project implementation: technical team and related technical and administrative support mechanisms were certainly one of the fundamental pillars of this project.

The support mechanisms can be roughly divided into administrative support for control and procedures for project progress report, administrative support for development of i-textbooks and technical support for development of i-textbooks. We will present the main tools, procedures, solutions and where it is justified, reasons for use and technical guidelines for achievement of required goals. Some important processes will be omitted e.g., searching for the most effective solution to a technical problem and development of pilot projects, with the help of which we always accomplished the most optimal solutions in use and confirmation of project guidelines.

Technical team began its work at the end of the initial coordination phase of the didactic-methodological team and will continue until the completion of the project. Products and procedures of the team will benefit and ensure quality and timeliness of i-textbooks even after the project, as can be seen from the basic idea of i-textbooks.

This article has the following structure: section 2 describes authoring tools for development and improvement of i-textbook content, while Section 3 presents the administrative portal as the focal point of all the procedures and content of the project. Section 4 contains final thoughts and instructions for development of future i-textbooks.

Tools

In this section we present the development of i-textbooks, implemented use of different authoring tools and technical environments. One of the most important authoring tools is eXeCute, which is a fundamental tool for recording and content composition of individual e-learning units. Technical suitability, as underlying technical basis of the project (i.e., maximizing independence of operating systems and devices), was achieved with the use of JSXGraph, MathJax, JSmol and standardized web programming language JavaScript. A dynamic generator of exercises and a collection of e-learning unit templates offer higher levels of interactivity and (active) teaching. This can also be achieved using a tool for dynamic geometry GeoGebra, but due to not meeting the requirements of aforementioned basic technical project baselines we stopped using this tool. Authors also used several additional tools for image, video and audio processing of recordings. One of the tools used was also ActiveInspire (www.prometheanworld.com), but it was used only by proof-readers and will be mentioned briefly in the following sections of this article.

eXeCute

The open source tool eXe (exelearning.org) and its modified version eXeCute (execute.fnm.uni-mb.si) were already used in development of e-learning materials in previous projects (Kelenc, Kos, Kren and Pesek, 2011). New guidelines for design and use of e-learning materials have made several developed materials somewhat outdated as they did not provide some of the necessary interactive elements. Despite a higher priority of content over appearance, we were constantly aware that i-textbooks will be designed especially for a younger generation, for which the external appearance of the material is an important factor. The technical team has modified these tools for development of learning content into a format that takes its final shape with some added important elements (Figure 1).

– Gap-fill: enables an option to create text with missing words, which are then entered in the input fields. An option is available to choose the length of the input fields (all fields can be the same length, or they can adjust to the length of a missing word), or to select the missing word by using a drop-down list.
– Linking: find correct pairs of terms, images, etc., arranged in two columns. Author inputs correct pairs which are then randomly distributed. The user then has to find these correct pairs. This is done by selecting one element in the left column and one in the right column (in a previous version of this exercise elements from the right column had to be moved to the left column, which made it difficult to use on tablet computers).
– Exercise: author inputs an identification tag of an exercise from the collection of exercises on the administrative portal that is connected to the exercise generator.
– Experiment: standardized instructions for experimental work - setting goals, supplies, procedure, results with text under buttons and adding additional files.
– Scenario: author can select an area reserved for an interactive element he will design in the future or will contract the technical team.

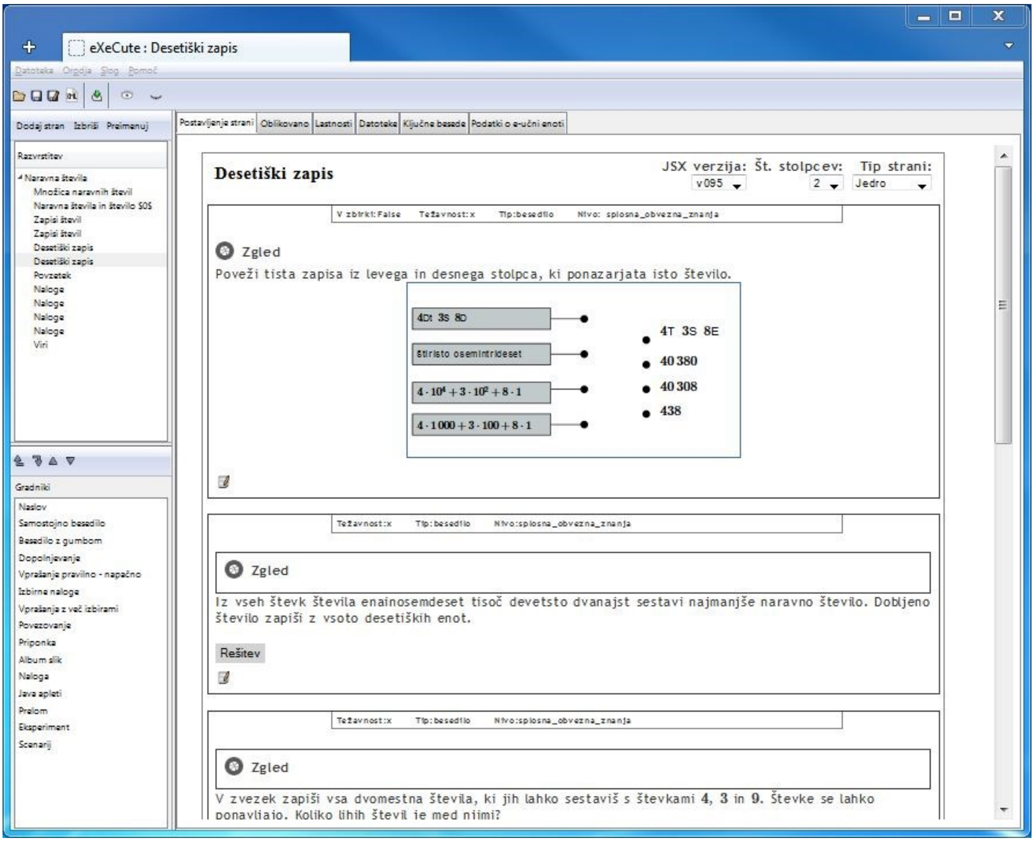

Figure 1: eXeCute user interface

All elements require these options:

- *content level*: general/mandatory, optional and specific knowledge. Specific and optional knowledge have a specific mark in i-textbooks.
- *level of difficulty*: three-level difficulty of exercises. Exercises have a specific colour that reflects the level of difficulty in i-textbooks.
- *content form*: text; an important fact, a definition, an activity, an interesting fact, add to a collection, activity, activity in a collection. Each form of content has its own shape or design.

This tool was used mostly by authors and the technical team. Editors, consultants and reviewers practitioners used it for revision of e-learning units. All versions of the eXeCute tool were downloaded from the administrative portal and tested by several authors.

Exercise generator

An important step, in the framework of the E-um project, was made in simulating teacher's experience in the development of an "infinite" selection of exercises for practical consolidation of knowledge. An exercise generator was developed, that generates a large amount of exercises based on one exercise definition (Prnaver, Pesek and Repolusk, 2009). Such functionality is perfect for i-textbooks.

The idea of an exercise generator was designed to enable authors to determine the dynamic of educational process solely by the use of mathematical symbols. It soon became obvious that additional features were needed, such as e.g., conditional statements, some advanced mathematical functions, choice of multiple responses in the results, etc. For this purpose a library of functions was developed to provide authors with a collection of functions that could be easily inserted into exercises.

Each exercise is determined by no (0) or more elements described below:

– A constant: a list of values determined by the author, which randomly appears in a form determined by the author through various displays. Constants are marked with ~.

> Example:
> ~name = Anna, Jack, Mike, Alice, Erica

– A variable: a variable that takes different values. It is determined by its lower and upper limit, precision, mathematical rules, rules from the library of functions, or even a combination of all of them. Pre-defined variables can be used in new variables. Functions from the library can also be used to define examples, when one variable is modified by another variable (e.g., a word is modified by sex, number, etc.). Variables are marked with @.

> Example:
> @grade = random integer from 1 to 9
> @verb = if name variable is Mike then "he", else "she"

– Result: defined similarly to a variable, but is displayed as an empty input field (or a list of possible answers), that a user must fill in and is then compared to the correct value. Result can be given in a form of a variable or a variable can be used as a result. Results are marked with #.

> Example:
> #age = @grade + 6

– Text: contains exercise instructions, non-editable text and pre-defined constants, variables and results. Elements that are modified by sex and number need to be set as variables.

Example:
~name is attending @grade. grade of primary school. If ~name enters primary school at the age of 6 and @noun birthday is on April 1st, how old will ~name be, at the end of school year in June?

Answer: ~name will be #age years old.

– Dynamic interactive elements: Some exercises require use of other tools interactive tools, which is why this field could, in its first phase, include Geogebra elements in form of Java applets and later JSXGraph element code. They are both described in the following sections. These dynamic elements, opposed to static elements, can be linked with variables, defined in the article above, and enable different presentations of graphic elements.

One of the best features of the exercise generator is a mechanism that can combine above mentioned elements and prepare them for the final display. So an exercise with a previously mentioned example could look like this:

Anna is attending 5. grade of primary school. If Anna enters primary school at the age of 6 and her birthday is on April 1st, how old will Anna be at the end of school year in June?

Answer: Anna will be ______ years old.

Or:

John is attending 1. grade of primary school. If John enters primary school at the age of 6 and his birthday is on April 1st, how old will John be at the end of school year in June?

Answer: John will be ______ years old.

Development of exercises demands skill and resourcefulness, especially with additional limitations; sometimes a unique way of thinking is required to get from result to variable.

The functionality of exercise generation, in the framework of the "E-učbeniki" (E-textbooks) project, was implemented into the administrative portal environment within the module "Exercises". It enables file uploads, setting the position of images, use of JSXGraph elements (more on the portal and JSXGraph in the following sections), input of button text for generated exercises, input of a solution description text and hints, as well as some new generator features and support for string constants. Authors have relatively quickly familiarized themselves with these tools and began creating their own exercises.

Each exercise has its own title, a short description and a difficulty level and is semantically connected to other e-learning units with an upload to the eXeCute tool.

JSXGraph

The use of Geogebra applets (www.geogebra.org) has been, as an integral part of materials, a great solution for implementation of interactive elements of previous projects. It soon became evident that the progress of GeoGebra demands better hardware, limits the use of several simultaneous Geogebra applets at once, does not work on some of the operational systems and causes problems for users and prevents the use of i-textbooks.

This is why we chose JSXGraph (Gerhäuser, Miller, Valentin, Wassermann in Wilfahrt, 2011; http://jsxgraph.uni-bayreuth.de/wp) as an alternative solution, which is a product of a group of mathematicians from Bayreuth University in Germany. JSXGraph has been in development since 2008, when its first version was released (https://www.ohloh.net/p/jsxgraph/factoids). Its library has since then been developing in functionality as well as in compliance with other new technologies.

JSXGraph is, opposed to GeoGebra, which is a mathematical tool that needs Java to display its content on web pages, a cross-browser library for interactive geometry, drawing of functions, graphs and display of content in web browsers. It is written in JavaScript programming language, is completely independent of other libraries and uses various graphical components and technologies for display of content. The size of the library is less than 100 KB and does not require any plug-ins, which makes it ideal for i-textbooks.

Another advantage of JSXGraph is MathJax support, an open coded mechanism for display of mathematical symbols and formulas in LaTeX data format. With the support of these libraries we enabled a unified and appropriate display of content in natural science i-textbooks.

The development of JSXGraph elements (jsx or jsx applets) demands more programming knowledge and experience then it would be reasonable to expect from authors. That is why the technical team conducted conversion of existing GeoGebra applets and development of new JSXGraph elements for e-learning units. Determination, to provide technical support to authors has demanded an organized conversion of GeoGebra applets on three levels:

– *Exercises:* an exercise was locked for editing and authors were notified about this through the exercise status field. If an exercise already existed in any previous e-learning units, authors had to update the exercise trough the eXeCute tool. In other cases a technically modified exercise was provided on its first use.

- *Existing e-learning units:* at the end of the first round of reviews (when author, editor, consultant and reviewer practitioner completed the content and interactivity of an e-learning unit) all e-learning units went through a systematic technical examination and conversion under supervision of the technical editor. The goal of this conversion was a consistent transfer of functionality of GeoGebra applets into JSXGraph elements with minimal loss of functionality.

- *Conversion:* authors were given an option to submit an applet for conversion, if they required a final version of a JSXGraph element in the starting phase of e-learning unit development. In doing so, they usually made a claim for amended functionality of an applet.

A web site with JSXGraph templates was also provided, which authors could use to design JSXGraph elements.

The GeoGebra to JSXGraph conversion had some shortcomings, but usability and versatility prevailed in search of new alternative solutions for depiction of specific examples. It should be noted that the team from the University of Bayreuth was always available to provide additional information on the use of JSXGraph tool, above all, to correct errors identified by the technical team. Even though JSXGraph is a library intended for use in mathematics, it soon showed that it can be used in other natural sciences areas like chemistry, physics, etc. It can also be used in social sciences; all it needs is a good implementation idea.

JSX-templates

A modern teaching approach demands active interactive teaching. The JSXGraph library is, at a first glance, a programme specific tool that does not offer development of interactive elements like GeoGebra. That is why our technical team implemented submission of conversion orders and later tools for development of JSXGraph elements. Only a few authors decided to submit an order for conversion with their own scenario.

The technical team also developed a website environment for development of JSXGraph elements with no requirements for programming language and algorithmic procedures knowledge. Created elements were ready for implementation into the eXeCute tool.

This new environment was titled "JSX-templates" because it includes development of JSXGraph elements with the use of templates, input of various parameters and images. All templates included an option to add text for a correct exercise solution. A button "Randomize" was also included in almost all templates, which reloaded the elements with new dynamic elements such as picture order, text, etc.

Authors could choose from the following JSXGraph templates:

– **Image gallery**: this template enables an automatic or manual picture slideshow.

An author could use this template in e.g., home economics class, a slideshow that shows a cooking process of a certain dish.

Figure 2: JSX image gallery template

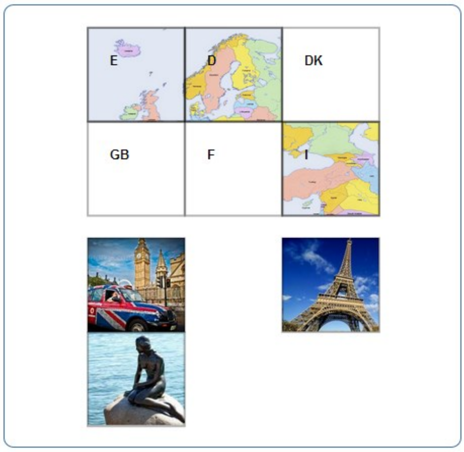

Figure 3: JSX puzzle template

– **Puzzle**: this template includes a JSXGraph element that consists of two m×n grids. One grid contains fixed elements that need to be connected with elements from the other grid. These elements can be pictures or text. On a correct connection of two elements a third image can be shown (Figure 3).

This element could be used in the geography class, where first grid could contain images of famous landmarks; the other grid would contain names of cities. A correct connection would display a map which shows a piece of the continent or a state in question. When a student would correctly connect all images and cities, a map of the whole continent would be shown.

– **Crossword**: an author must enter horizontal and vertical coordinates for keywords and their direction (horizontal or vertical), a programme then generates a crossword, which can be used in a learning unit (Figure 4).

This element can be used for all subjects. A cross number puzzle (Cross-figure) was developed specifically for science classes.

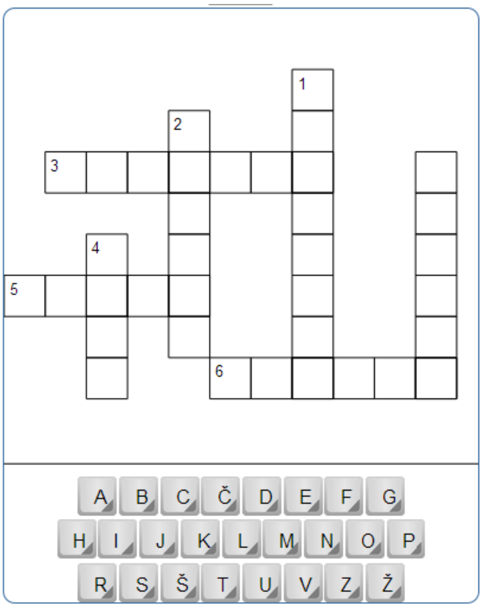

Figure 4: JSX crossword template

– **Linking:** this template enables authors to create a simple element, which includes linking of correct elements from two columns. These elements can be pictures or text, linking can be done with lines or moving the elements from the right column to the correct pair in the left column. (Figure 5).

This template can be used in all subject areas. In history class e.g., an author could create an exercise where important events have to be linked to a specific year.

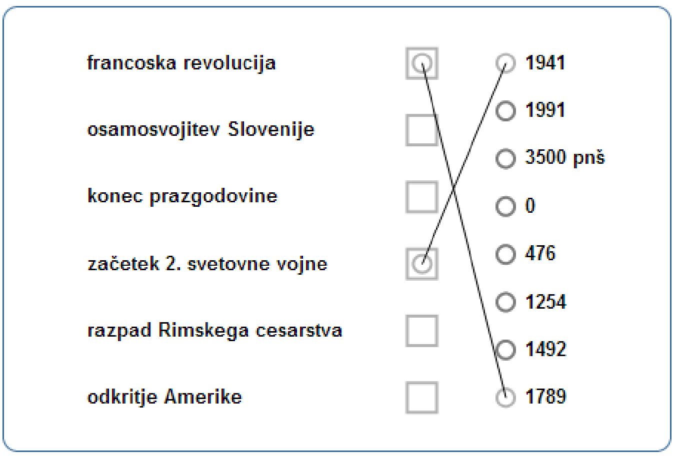

Figure 5: JSX linking template

– **Memory**: an element that simulates the Memory (Concentration) card game. Two versions of this game were developed; one where a user has to find identical pairs and one where a user has to find pairs that make sense (Figure 6).

In physical education class, an author could create an exercise where sports had to be matched with appropriate gear.

Figure 5: JSX memory template

– **Function approximation**: a template used mostly in natural science classes. An author determines a number of fields in a table and the way of drawing a function. An element is then generated that contains a table and fields with coordinates. A graph is then drawn with points (coordinates from the table) with a curve between them.

In physics class, an author could create a table with a specific linear approximation for determining the gradient of the line in an experiment, and thereby determining its characteristics e.g. a rising or falling gradient.

X	Y
0	0
1	4
2	5
3	6.5
4	9.2

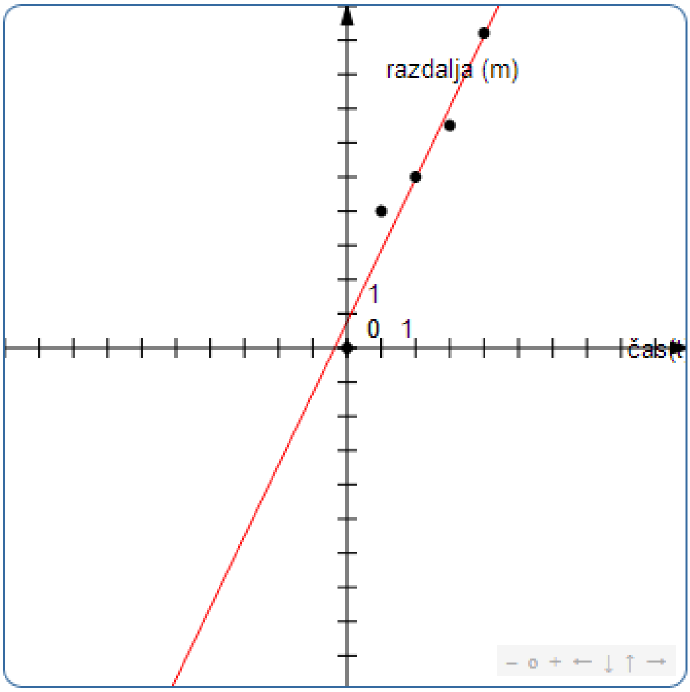

Figure 7: JSX function approximation template

– **Fill-in and link**: This template functions the same as the linking template; the only difference is that it includes a text field between two columns.

This template can be used in English class for teaching sentence elements. The left column would contain each word from the sentence (Jake, is, watching, TV), right column would contain specific marks for sentence elements (-----------, ======, ~~~~~~~~~, ...), field in between columns would contain sentence element name (subject, verb, object, adverbial).

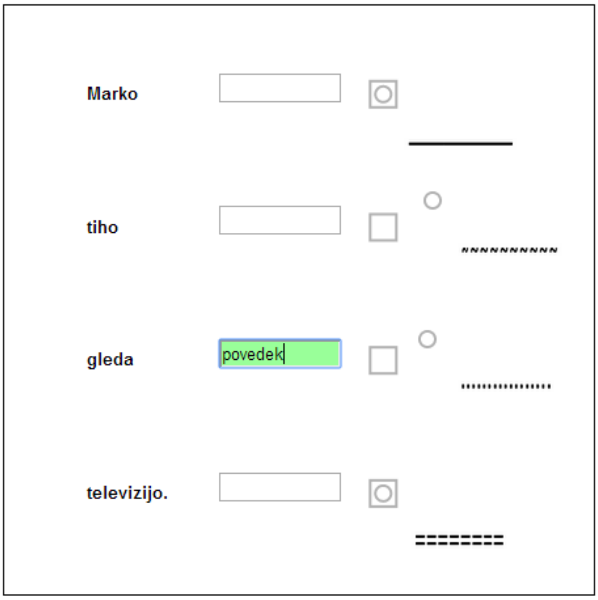

Figure 8: JSX Fill-in and link template

– **Sort**: this template requires images to be uploaded in a specific order with a set direction of the sequence (vertical or horizontal). Images are then randomly distributed on a horizontal or vertical line and the user has to sort them in a correct sequence (Figure 9).

In chemistry class this template could be used to sort different molecules according to their molecule mass.

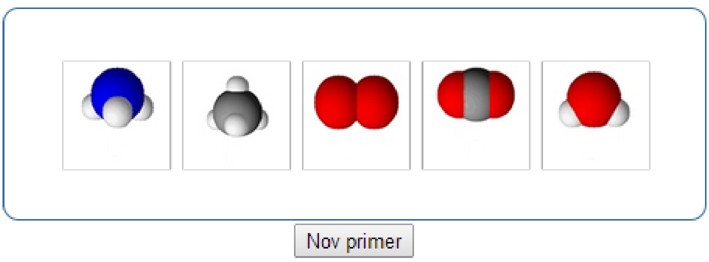

Figure 9: JSX sort template

– **Picture association**: an author must select an image, which will be displayed on the left side and several more images or text on the right side (Figure 10).

This template could be used in technical education class for learning about the perpendicular projection. Left side would show an image of an object, right side would show a floor plan, site plan, elevation, etc.

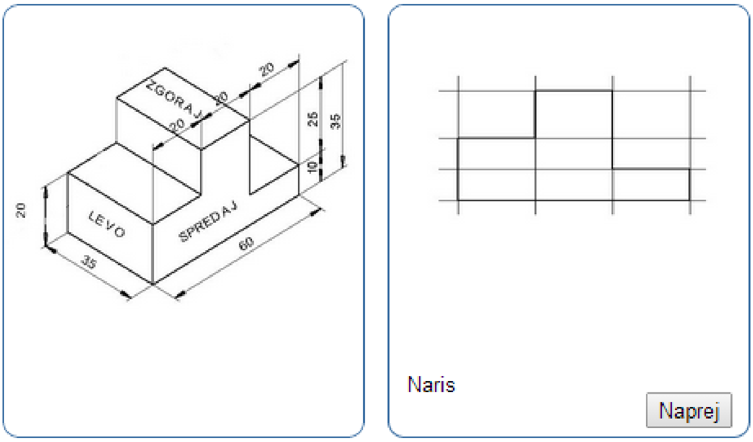

Figure 10: JSX picture association template

– **Link the image**: the base of this template is a picture on which a user must transfer text or other pictures. The development of this template is carried out in two steps. First a background image must be uploaded, then an author marks correct spot for other images or text with a mouse click (Figure 11).

As a result, an element is generated where a user must transfer or link images or text from the right side on to the background image. This template can be used in biology class, where the base image could be a picture of a cell with lines marking specific cell parts. The user would have to transfer names from the right side to appropriate lines on the background image e.g., text "Ribosome" would be transferred to a line that is linked to a ribosome of a cell.

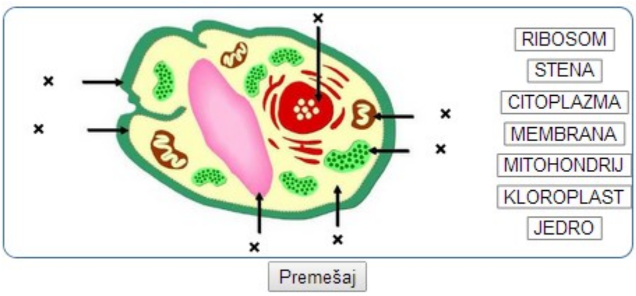

Figure 11: JSX Link the image template

– **Gapfill**: this template contains a text with empty field between two # marks that need to be filled in with appropriate words. This template includes an option to add incorrect words (Figure 12).

A text with empty fields is generated. Below this text are several words in a random order that have to be transferred to correct fields in the text. This template can be used in all subject areas.

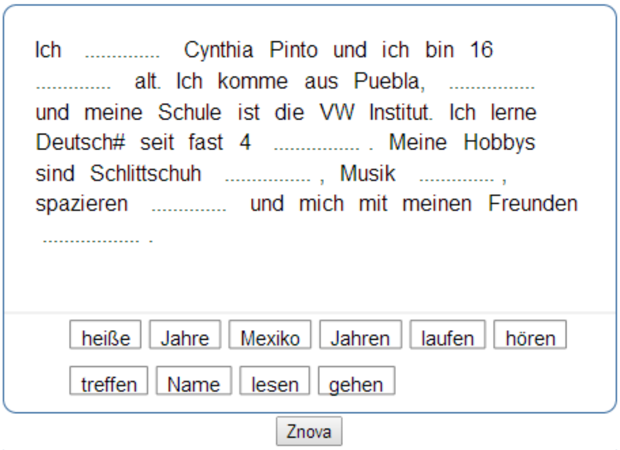

Figure 12: JSX gapfill template

These JSX templates have made development of exercises a lot easier for authors with a lower technical knowledge. It enabled them to include high level interactive elements into their e-learning units.

JSmol

Until recently, a software tool Jmol (jmol.sourceforge.net) was used in online published chemistry literature (as independent e-materials, Moodle, etc.) to display molecules, structures and for 3-D interactivity. The open source project Jmol is widely used in the field of chemistry and biochemistry for a dynamic display, as well as a rich library of molecule properties, atomic bonds, interactive states and cell motility. This system offers molecule, structure and shape assembly, as well as a connection to libraries with existing materials and display of these molecules and structures. A lot of these libraries are free and publicly available, but some are payable (like encyclopaedia).

Even though it offers some great functions, Jmol has some disadvantages. It is based on the same platform as before mentioned GeoGebra (Java) and it causes some difficulties in use on other operating systems and devices. The technical team had to find an alternative solution. The ChemDoodle (www.chemdoodle.com), commercial software, was excluded as an alternative and Jsmol was selected as the most appropriate software to resolve this issue.

In the year 2012, a group of developers began their work on the open source JSmol project (jsmol.sourceforge.net) to replace the java display of molecules in Jmol by using JavaScript programming language and HTML5 standard. The description of structure and shape of molecules remained basically the same, the only difference is in the display of this information (in a web browser the Java Script library is used to display this content with no additional plug-ins needed). These molecules can also be displayed in web browsers on smart phones (Figure 13).

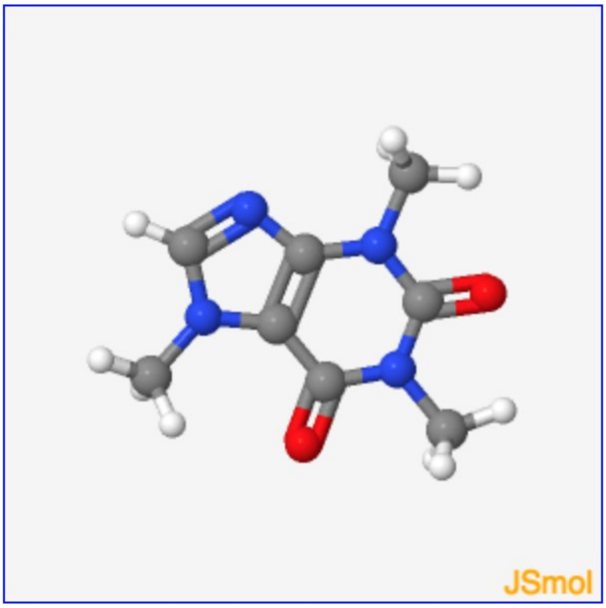

Figure 13: ActiveInspire user interface

Similar to the GeoGebra to JSXGraph conversion, the technical team made a conversion from Jmol to JSmol. With some adjustments and modifications, all i-textbooks from the field of chemistry now contain molecule displays and 3d animation content in JSmol environment.

Tools for proofreaders

All phases of i-textbook development include aforementioned tools, environments and the administrative web portal. The proofreading team had to adapt to the digital work environment. Proofreaders are used to using standard text editors and word processors (e.g., Microsoft Word) and the "Track Changes" function.

The eXeCute authoring tool does not include a "Track Changes" function or adding comments, it also does not provide any standard proofreading and style tools because of its integration with the administrative web portal and JSX templates. The technical team had to find a solution, dedicated computers, dedicated software, etc.

The proofreading team had to use i-textbooks and e-learning units in the same way as the end user. They had to download specific learning units and upload them to eXeCute, or they used them directly on the administrative web portal. All notes and suggestions were given in a form of a screenshot and uploaded into the ActiveInspire application, created by Promethean (www.prometheanworld.com). The application (Figure 14) is intended for use with an interactive whiteboard, with the option of reading and writing (with a mouse and a keyboard instead of an interactive pen). This solution forms a compromise between proofreaders and other users e.g., authors, editors and a technical editor. With the use of this software we avoid printing, expensive software and scanning of revisions (Figure 15).

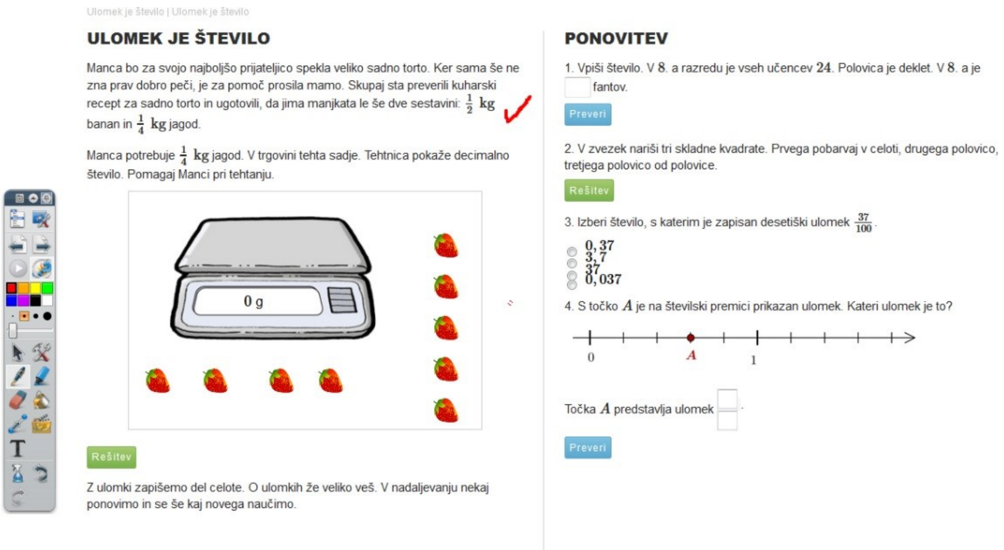

Figure 14: ActiveInspire user interface

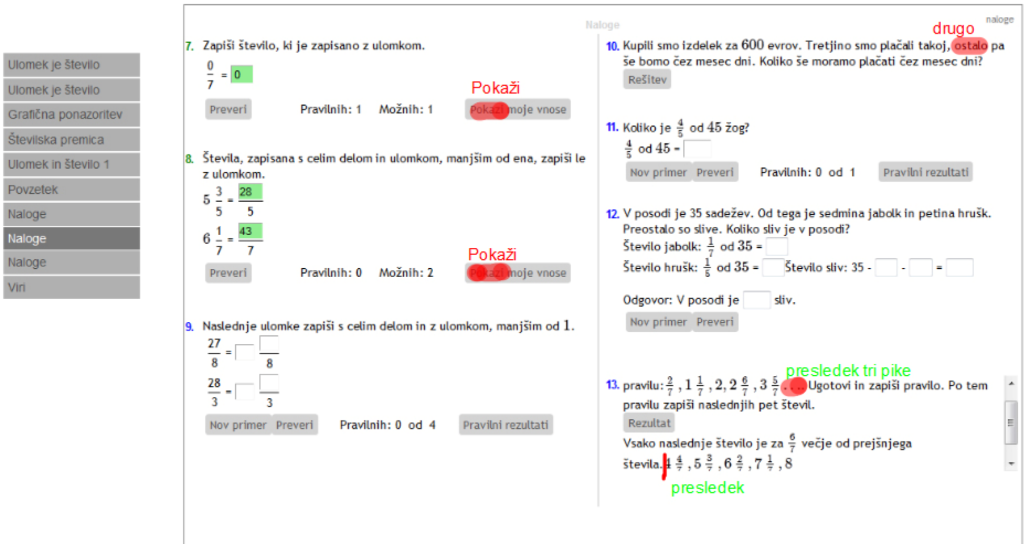

Figure 15: A screenshot with proofreading revisions.

Administrative web portal

The administrative web portal is a web application designed for organizing and digital storage of e-learning material (Figure 15). It is a starting point and a source of information for development of i-textbooks and e-learning units and is meant for different types of users. The use of this portal is password and username protected. It can be accessed with web browsers like Internet Explorer, Google Chrome, Mozilla Firefox, Safari, Opera, etc.

The administrative web portal is based on a modular design and a mechanism controlling specific process stages of i-textbook development. Some modules have a role of coding systems (e.g., subject areas), collecting data and information for later use (e.g., material used in previous projects, lesson plans, curriculum goals), while other form the core of functionality of the portal (i-textbook design, e-learning units content, reviews, comments, exercises, requests for payment, proofreading, etc.).

Functionality of the administrative web portal is limited to a user type. The basic functionality includes the use of modules, limited content and limited activities.

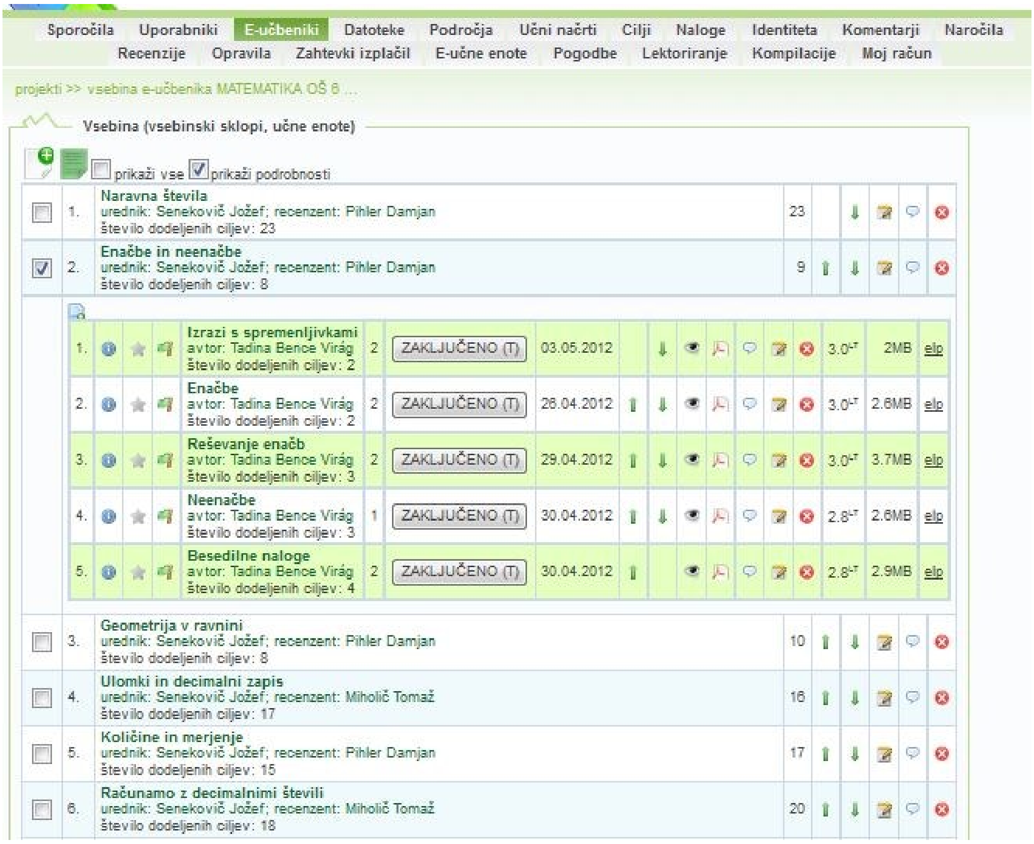

Figure 16: Administrative web portal user interface

The portal supports the following types of users:

– *Editor*: determines allocation of content and curriculum goals and assigns and supervises the work of authors. Each i-textbook has one (central) editor or additional editors for specific content sets.

– *Author:* the portal is a starting point and a source of information for development of e-learning units. All created e-learning units are collected on the portal, which also offers user support for authors, so they can get assistance for development of specific elements of their e-learning units.

– *Consultant:* the portal is a tool for review of i-textbook development. The review form offers a view of previous reviews and adding new suggestions on the consistency of e-learning units with the curriculum.

– *Reviewer practitioner:* the portal offers the same functionality to a reviewer practitioner as to a consultant, with a focus on methodical-didactic consistency.

– *Expert reviewer:* the portal offers the expert reviewer tools for a review of i-textbooks. The expert reviewer focuses on content consistency and interactivity with contemporary knowledge of different subject disciplines.

– *Technical editor:* receives e-learning units for a second round of review, checks adequacy and functionality of interactive elements as well as technical adequacy of the unit.

– *Proofreader:* receives and reviews e-learning units, uploads revisions and monitors their implementation.

– *Technician:* the portal offers information and procedures for technical preparation of e-learning unit elements submitted by other users, a comprehensive technical processing of e-learning units after the first stage of preparation and technical execution of exercises.

– *Management:* the portal offers a view over the activities of development of i-textbooks.

– *Administrator:* has administrative rights on the portal, can intervene in the i-textbook development process, even on behalf of other users, when necessary, by taking over their identity.

Overall functionality of the web portal

All users have access to a "My Account" module, an entry point to the portal and the "Messages" module, for messages.

The "My Account" module is a "personal control panel" for users. It contains a "Support" tab with a list of files and useful web sites (e.g., didactic and technical project guidelines, presentation of a project, LaTeX instruction manual, authoring tool eXeCute and GeoGebra, eXeCute sample material, videos of seminars, portal instruction manual, forum entry point, JSX templates, image material, applications for image and video processing, Java environment, etc.). Depending on the user type, a list of owned e-learning units, last uploaded e-learning unit material and sample e-learning units are also shown.

Users can send and receive messages from other users or the system itself. They are always shown above the menu and contain a "[task]", which redirects a user to a part of the portal, where he can execute this task (e.g. review a learning unit). All users that have an email address included in their user information, also receive all their messages to their personal email. The user can receive two types of emails:

– *message on the portal*: immediately or in a couple of minutes, after the user receives a message;

– *unread messages*: after 48 hours, if a user has not confirmed he read a message.

Messages were not the only form of communication between project participants. Participants also communicated through comments (e.g., orders, first reviews of i-textbook index tree, proofreaders notes and submitting e-learning units), forum or classical e-mail. All users had an option to contact technical support, where the technical team responded and helped improve authoring tools and environments.

I-textbooks on the web portal

Each i-textbook was handled as a sub-project of the "E-učbeniki" (E-textbooks) project. They were based on the curriculum, curriculum goals and files and exercises from previous e-materials.

In the initial stage of i-textbook development, the technical team transferred operational objectives of each subject area or curriculum to the web portal. Goals were sorted by chapters and/or content sections. Mandatory, optional, general and special knowledge (as goal subtypes) were specifically marked. Each i-textbook was recorded in the "E-učbeniki" (E-textbooks) central module, with set subject area, level, class, curriculum and an i-textbook editor.

Editors sorted all i-textbooks according to content section and e-learning units. The editor took into consideration all objectives in preparation of an index-tree, instructions and notes to authors and included them in each unit. Editor also set the level of knowledge (specific or optional) and gave detailed instructions (samples from previous projects, sample sets of exercises, content goals, exercises, interactivity) to authors on the content of each specific e-learning unit. An author could begin his work when the editor assigned a specific e-learning unit.

When an e-learning unit was under development in the "E-učbeniki" (e-textbooks) module, editors had access to all information associated with an i-textbook: monitoring progress, submitting and receiving reviews, monitoring editorial changes and technical inspection details. All activities related to i-textbooks are stored and can be accessed on the administrative web portal trough specific e-learning unit information. The i-textbook index-tree, on the other hand, shows only the last known state, the last uploaded file.

Each phase of i-textbook development has an assigned consultant, reviewer practitioner, technical editor and a proofreader. For i-textbooks covering multiple subject areas, additional editors are assigned according to a specific subject area (content set).

Tools for authors

Authors have most frequently used the following modules on the administrative web portal: "E-textbooks", "Exercises", "Orders" and "My account".

– E-textbooks: Authors had access to content where there were co-authors. They could access information for each e-learning unit: instructions, notes, goals, coverage, network cohesion, sample set of e-materials and exercises. This includes information on progress of i-textbook development and last uploaded e-learning unit of other co-authors.

For their own e-learning units, authors had their own set of expanded rights. They could assume a unit for production; see an archive of all uploaded files and all previous editorial reviews. After the first round of reviews, author could monitor the technical processing phase, proofreading and proofreaders' notes.

Their goal was to meet the quality requirements and set the status of an e-learning unit to "complete". Due to the specifics of an i-textbooks such status does not necessarily mean that it is actually completed. If any errors are discovered, one can reassess a unit for improvement and complete it.

– Exercises: The "Exercises" module shows and offers all exercises developed in previous projects and the ones developed in the "E-textbooks" project. Any exercise can be used in an e-learning unit and the administrative web portal provides information on who the author is and if an exercise was already used in any other e-learning unit. Use of each exercise in the eXeCute tool locks the unit for editing, which is why cloning of exercises was made available, so that other authors could create a similar exercise.

The authors developed a significant amount of exercises with the use of an exercise generator. When they designed an exercise, all they needed was an identification code for the exercise in eXeCute tool to transfer it from the portal to their unit.

– Orders: Orders were issued when an author wanted to process or develop a new interactive element; in most cases this involved a technical implementation of complex situations. An order was submitted through the "Orders" module or through the "My Account" module under "My learning units".

More than thousand orders were issued.

As we assumed, orders helped quicken the work of authors, as it relieved them of technical issues, so they could concentrate on the content and didactic topics. The communication between an author and a technician was made easier; it took place on one specific place and was stored in a specific order, so that the history of communication was available to both, the author and the technician.

- My Account: The module was comprised of several areas. The most important area for authors was "My learning units", as it provided an option to upload units to the portal. It provided information about the unit, its status (development phase), editorial document in a PDF format, view and submission of comments for a specific e-learning unit and download of the original file. Submission of orders for technical processing was available for each specific unit.

Tools for the technical team

The technical team used the same modules as authors, but in a different way and with different functionality.

- E-textbooks: When a unit is completed, after editors, consultants and reviewer practitioners complete their review, it becomes available for proofreading or technical processing. The technical team took over a unit after it was processed by proofreaders to avoid re-corrections.

The largest part of processing was conversion of GeoGebra applets into JSXGraph applets and some other smaller issues and technical errors. The technical inspection was carried out in accordance with the technical editor, the exchange of findings and upload of processed units took place in the informative view of an e-learning unit in the index-tree. If proofreading corrections were implemented and a technical editor approved an e-learning unit, it received a "completed" status and was ready to be used in an i-textbook.

- Exercises: The largest part of processing was conversion of GeoGebra into JSXGraph, with some exercise modifications and corrections ordered by the author (trough orders or email to the technical support). The technical team had a right to lock or unlock an exercise for modification.
- Orders: Orders were submitted in two steps. The administrator examined each order and approved or rejected it. If an order was incomplete or unclear an author had to complete and resubmit the order.

Each technician chose an order from a list of approved orders, locked it for editing and took it into processing. When an order was complete the technician uploaded the file, wrote commentary and completed the order. The author then used this file in his unit or ordered additional corrections or completion of an order.

For administrative reasons, record and statistics, a technician had to file a report for each order with the following information: interactive element type, number of uploaded files and an identification code for a similar order if one existed. A free choice of orders enabled the technical team to supervise and organise its work and any other priority tasks.

Life cycle of an e-learning unit

High quality of e-materials can be achieved with a revision process (Prnaver, Pesek, Zmazek, 2007; Prnaver Šenveter, Zmazek, 2007) that specifies the sequence of quality inspections from the first to the last version ready for a release.

A similar concept was used in the "E-učbeniki" (E-textbooks) project. The status and a current editor were always monitored for each specific e-learning unit. The users got the same roles in different life cycles of an e-learning unit as they did on the administrative web portal (Figure 17).

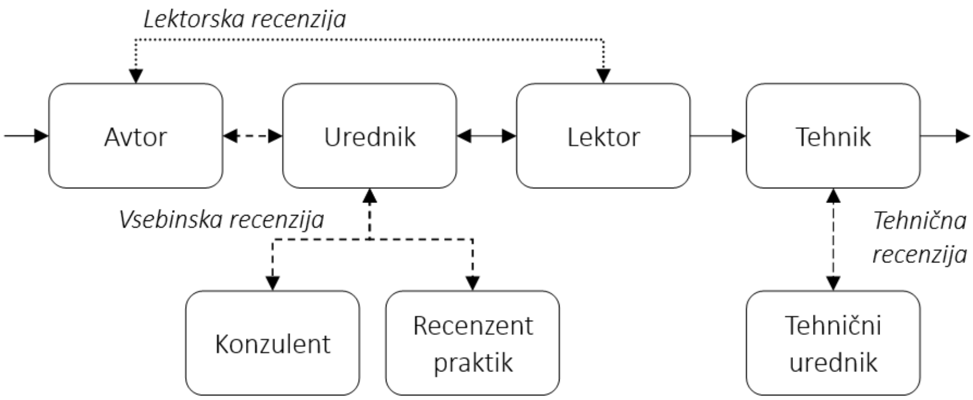

Figure 17: Schema of user roles in a life cycle of an e-learning unit

In the first review round, editor, consultant and reviewer practitioner had a major role, while author took care of the content. Editor was a mediator between an author and other actors in a review. After each completed round of reviews, a consultant and a reviewer practitioner each provided their own review from which an editor formed a review report and forwarded it to an author for changes or adaptations.

Only after all of the actors confirmed the material as complete and ready for publishing was a material marked as complete in the first stage and ready for proofreading. The suitability of materials was marked with a + or a -. The + mark was final and meant a work of a certain actor was completed.

For technical reasons, mostly related to the conversion of GeoGebra to JSXGraph, a technical review was performed after proofreading. A technician processed an e-learning unit and took into consideration all of the review comments made by a technical editor. An extra review round was then formed, that included only a technician and a technical editor.

The status of a unit informed all participants of their turn and enabled monitoring of an e-learning units life cycle. After review rounds are completed, an editor can still upload an improved version of an e-learning unit, to upgrade or to implement any other modifications.

Because of a great number of participants in the reviewing process, it was necessary to introduce time limits for reviews. Consultant and a reviewer practitioner were given a deadline by which they had to submit their reviews. This mechanism enabled a constant control over the progress of an e-learning unit and ensured that set objectives were met.

The need for a modified process of certain i-textbooks brought an addition to the i-textbook life cycle. After a final review was completed, several additional arrangements had to be made with an editor and/or an author. A technical editor could also suggest a change that had an influence on the content. A decision was made that all actors whose comment could have an impact on the content were included in the primary (content) round of review. With an added role of an expert reviewer and the change of functionality of a technical editor, that became a technical reviewer, the whole life cycle changed (Figure 18).

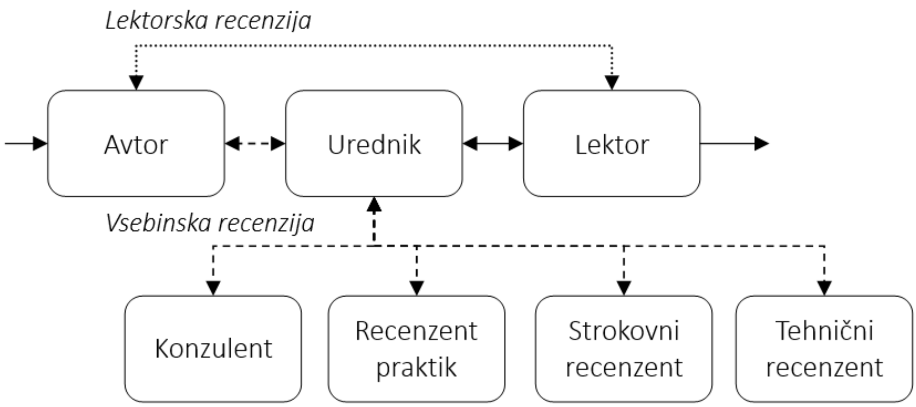

Figure 18: Revised schema of user roles in a life cycle of an e-learning unit

Proofreading support

Proofreaders provided support for their assigned i-textbook. They mostly used the "E-textbooks" and "Proofreading" modules. To enable parallel work on preparation of e-learning units and the work performed by the technical team, the basic working unit of a proofreader was an e-learning unit. When proofreading was in progress, the whole review group was notified.

The "Proofreading" module contained a list of e-learning units that were undergoing proofreading and other vital information. It clearly showed if proofreading was in progress or already completed.

Figure 19: A list of e-learning units undergoing proofreading

A proofreader had an option to see all information about e-learning units, i-textbooks and the whole e-learning unit. Pilot testing has shown that proofreading was made easier if proofreaders were given an option to download e-learning units and work in their own environment.

As we mentioned before, the preparation of proofreading documents was made in a pre-agreed manner, in which proofreaders prepared their files in standard formats (PDF or images) to be reviewed by editors or authors. Proofreaders then uploaded their corrections on the administrative web portal. If they labelled the uploaded files as final, the files were sent to an author and editor and were open for commentary.

When authors uploaded materials of an e-learning unit with proofreading corrections, the proofreaders were notified and were given commentary on corrections that were used. Authors had a right to decide which corrections they will implement and which they will not, but with commentary. A proofreader could then review the content based on the commentary or other information and give an opinion on changes made.

Analytical control of the project

Achieving the set project goals, a greater amount of i-textbooks, e-learning units and actors involved in the development process, was a considerable challenge. It was necessary to inform people of achieved milestone points. This functionality was taken over by the administrative web portal, which informed authors and editors of their scheduled achievement of goals.

The administrative portal also offered static surveillance over the division of labour and coverage of goals in the "E-notebooks" module, "E-learning units" module and offered information on the amount of work completed.

Users and editors with management rights could see the following information in the "E-textbooks" module:

- average assessment of content coverage, exercises and interactivity of previous e-material projects,
- number of operative and general goals set by the curriculum and achievement of them in a specific i-textbook,
- total amount of e-learning unit hours in an i-textbook and all i-textbooks,
- total amount of e-learning units in an i-textbook and all i-textbooks,
- amount of e-learning units in different phases of development: amount of uploaded e-learning units, amount of completed e-learning units after a review of consultants and reviewers practitioners, amount of e-learning units undergoing proofreading, amount of e-learning units in review by a technical editor, amount of e-learning units in technical processing and
- a percentage of achieved goals in different phases of development: amount of e-learning units in relation to a total amount of e-learning units.

The "E-learning units" module offered a different analytical view of goal achievement: the amount of work and support in preparing financial claims for authors, editors and reviewer practitioners. For each e-learning unit and i-textbook the portal analysed and created report on:

- amount of reviews by editors, consultants and reviewers practitioners,
- amount of files of an e-learning unit: total amount of files, ggb files, HTML files, images (total and individual amount of GIF, PNG, JPG and BMP files), videos (total and individual amount of WEBM, OGV and MP4 files), jsx files, audio files (total and individual amount of MP3 and ogg files), SWF files,
- amount of JSX templates used,
- amount of pages in an e-learning unit,
- amount of uploaded versions of an e-learning unit,
- amount of characters in an e-learning unit.

The management and the editorial team then formed a prediction of future work based on this information.

Conclusion

The work of the technical team was integrated with the work of other project actors. Several tools and environments were developed for authors with the help of which they created i-textbook content, accessed vital information and elements.

Editors' work was supported by a tool for development of an i-textbook concept and management of development of individual e-learning units and i-textbooks. The same tool, but with a different functionality, was used by consultants and reviewer practitioners to review and monitor the project progress. Technical modifications and technical reviews, with the help of which i-textbooks achieved the goal of maximizing technical independence from operating systems and devices, was a very specific form of work.

This article presents a short summary of main tools, environments and a revision mechanism. It also mentions some other activities performed by the technical team, whose details are left out. Every development of a new prototype product, which i-textbooks definitely are, involves a lot of research, searching for alternative solutions, developing test products, extended testing, adjustments and redeveloping. This is why a technical team of this and future projects must be persistent, accurate, critical, organized and have a great team spirit.

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JSXGraph in i-textbooks

Alfred Wassermann, Darko Drakulić, Igor Pesek, Blaž Zmazek

New handheld devices provoke new challenges for interactive mathematics visualization software, and the main characteristic is the independence of the content from the platform. The second requirement is that the content must expend as few resources as possible in terms of memory, time and energy. Many of today's platforms for the development of interactive elements have been developed primarily for use on desktop computers, and almost all are based on Java and Flash technologies. This approach is not suitable for use on tablets, and it is necessary to offer a new solution to overcome this gap. In this paper, we present the technological background for content development based on JavaScript. We also present some JSXGraph applications and their integration into Slovenian i-textbooks.

Key words: mobile learning, interactive textbooks, JavaScript, JSXGraph

Introduction

Using computer technology in mathematics education has been a very active research area at least since the availability of personal computer in the 1980s, (see Hoyles and Lagrange, 2010; Google Caja, 2012). Arguably, for many years one of the biggest obstacles to the integration of computer technology into mathematics education has been the necessity for a computer laboratory. Usually, the class has to stay in the laboratory for the whole lesson; however, most computer laboratories are filled with large computer screens, and the tables are covered by keyboards. In such an environment, regular paper-and-pencil work is limited. This may have been one of the reasons why many teachers restricted the use of computer technology to presentations of dynamic content in front of the class. On the other hand, modern education extends beyond the boundaries of school, and students are increasingly using personal computers and other electronic devices for learning outside school. In this environment, the concept of mobile learning has appeared and has been evolving rapidly. This concept is clear: students must be able to learn from anywhere, at anytime, and on any device.

With the presentation of the Apple iPhone in 2007 and the Apple iPad in 2010, followed by a plethora of mobile devices with constantly dropping prices, the situation changed entirely. This new generation of mobile devices is well suited for the classroom. Envisioned with astonishing precision 40 years ago by Alan Kay, one of the pioneers in proposing computers in education (Kay, 1972), tablets are now available to everyone. In contrast to the use of desktop computers in a computer laboratory or at home, working with tablets blends well with paper-and-pencil work. There are no more physical borders – students can learn at any place – in the classroom, at home, or in any other place: "Because mobile technology … [is] becoming increasingly relevant for mathematics education" (Drijvers, 2012). This movement is amplified by the efforts of several countries to replace printed textbooks with electronic ones. This evolution of textbooks has a strong didactic motive: in 2012, Professor Janna Quitney Anderson (Anderson, 2012) from Elon University described the generations born from 2000 to 2020 as "always on generation", and the lives of these children are strongly connected with the internet. For the first time in history, the internet and electronic materials have become the main source of knowledge, replacing printed materials. Among the countries which plan to switch to electronic materials, there are Slovenia, South Korea and the United States (Lederman 2012). As a consequence for the future, educational software will have to blend well with electronic textbooks. These could be divided into several groups according to the degree of interactivity. Interactive textbooks or i-textbooks represent the most advanced form of electronic textbook, and comprise various interactive elements.

The availability of these handheld devices, along with i-textbooks requirements has provoked new challenges for interactive mathematics visualization software (Wassermann, 2012). Today's dynamic mathematics software is expected to be usable on desktop computers as well as on mobile devices. Software developers, therefore, have little choice but to use a platform independent design. At the time of writing, the only software standard that can run on desktop computers and simultaneously on the vast variety of mobile platforms is the HTML5 quasi-standard. This is the common denominator for software which is available on the Android, iOS and desktop systems (Windows, Mac OS X and Linux). In technical terms, this means the user interface has to be realized with HTML and CSS, for graphics is SVG (scalable vector graphics) and/or the canvas DOM-element. The programming language that glues everything together is JavaScript.

One advantage of using HTML5 is that e-books are essentially based on the same technology. For example, the e-book file format standard epub3 is based on large parts of HTML5. Many HTML5 applications can, therefore, be included in e-books and enable a previously unknown interactive reading experience. This means the borderline between software and e-book no longer exists.

Most authors of content have no significant experience in software development, and coding in JavaScript is a major obstacle in the process of creating textbooks. They need help from programmers or/and powerful authoring tools, JavaScript libraries and scripting languages in the development of interactive elements. In this paper, the authors present the results from and their experiences with the development of a JavaScript library for interactive geometry with a scripting language for describing construction, and authoring tools for making interactive elements.

JSXGraph library and JessieCode

This section gives an overview of two software projects developed by the authors. JSXGraph (http://www.jsxgraph.org), and JessieCode (http://github.com/jsxgraph/ JessieCode) are based on HTML5 technology and can therefore be used on practically all mobile computers as well as on desktop ones.

JSXGraph is a software library for dynamic mathematics. Its user group consists of software developers, developers of mathematics visualizations and the authors of e-books.

While JSXGraph offers the full power and flexibility of a software library, the third project, JessieCode, is a middle layer between JSXGraph and application software. It allows the use of a mathematically oriented language to create constructions. Additionally, it provides the necessary security measures to be used as a communication language for mathematics in public web forums or wikis.

JSXGraph

JSXGraph (Gerhäuser, Valentin and Wassermann, 2010; Gerhäuser, Valentin, Wassermann and Wilfahrt, 2011) is a cross-browser library written completely in JavaScript, which enables function plotting, data visualization and interactive geometry on a web page. First presented in 2008 (Ehmann, Miller and Wassermann, 2008), it provides a powerful and extensive API consisting of several hundred classes and methods (http://jsxgraph.uni-bayreuth.de/docs).

point	axis
line, segment, ray	slider
circle, sector, arc	glider point
intersection points	text
conic section	image
curve, function graph	perpendicular, parallel
parametric curve, polar curve	bisector
plot	turtle
polygon, regular polygon	projective transformation
tangent	integral
slope triangle	splines, Bezier curve

Table 1: Overview of objects available in JSXGraph

In order to use JSXGraph on a web page, one has to reserve a DOM element for JSXGraph. Usually this is a `<div>` element. The element has to be empty and should contain width and height specifications.

```
<div id='box' class='jxgbox' style='width:600px; height:600px;'></div>
```

The JSXGraph code is linked to this element by using its ID, i.e., the ID box in our case. With the property `boundingbox:[x1,y1,x2,y2]`, it is possible to specify a coordinate system. The upper left corner of the div will have the `coordinates (x1, y1)`; the lower right corner will have the `coordinates (x2,y2)`.

```
<script type='text/javascript'>var board = JXG.JSXGraph.initBoard (
'box',{boundingbox:[ -1.5,2, 1.5,-1]});</script>
```

There is no restriction on the number of JSXGraph boards in a web page. After initializing the JavaScript object `board`, it is ready for the construction of geometric elements. The generic call to create a new geometric object has the following form:

```
board.create('type', [parent elements], {optional properties});
```

Possible types are point, line, circle, polygon and `function graph`, to name a few. For example, the call of

```
var A = board.create('point', [1,0]);
```

will create a free point initially at `(1,0)` which can be dragged around. While dragging an element, all elements of the board are constantly updated. If there is an additional point

```
var B = board.create('point', [-1,-1]);
```

we can create a line through these points by

```
var s = board.create('line', [A,B]);
```

The optional properties are specified by key-value pairs separated by ":". If there is more than one pair, they are separated by comma.

```
var C = board.create('point', [0,1], {name:'D', color:'blue});
```

If an element contains sub-elements, like the border segments of a polygon, then the properties of these sub-elements can be accessed as JavaScript sub-objects.

```
var t = board.create('triangle', [A,B,C], {fillColor:'red', fillOpacity
:0.1, borders: {strokeWidth:2, strokeColor: 'black'}});
```

Function graphs can be specified either as a JavaScript function or as a string containing the usual mathematical syntax.

```
var f1 = board.create('functiongraph', [function(x){return x*x;}]);
var f2 = board.create('functiongraph', ["cos(x)"]);
```

One major advantage of a JavaScript based library is seamless integration into HTML files. It is quite natural to use HTML form elements to interact with a construction. The following code is an example of an HTML button which allows the user to create random points.

```
<script type='text/javascript'>
var p = []; // Empty array for points.</script>

<input type='button' value='New point' onClick='p.push( board.create('p
oint', [Math.random(), Math.random()]);' />
```

Since by default JSXGraph text objects are HTML div objects, it is possible to use any HTML code inside a JSXGraph text element.

Communication from a JSXGraph construction to an HTML DOM object is also possible. For example, if the coordinates of a point `P` should be displayed in an HTML form element, it can be done as follows:

```
<input type='text' value='' id='output' />

<script type='text/javascript'>
var P = board.create('point', [Math.random(), Math.random()]); board.on
('update', function() { document.getElementById('output').value = P.X()
 + ' ' + P.Y();});</script>
```

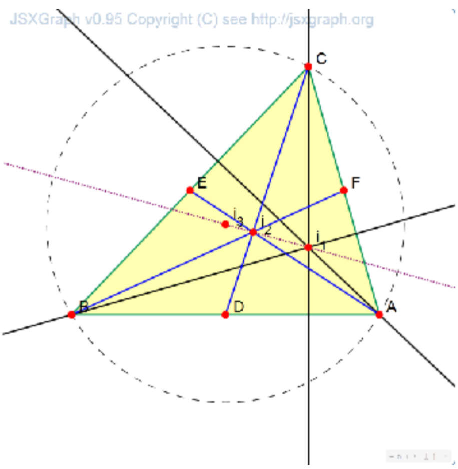
Comprehensive documentation describing all available elements and all possible properties is available at http://jsxgraph.uni-bayreuth.de/docs. The JSXGraph wiki at http://jsxgraph.uni-bayreuth.de/wiki contains many examples.

If one wants to avoid construction by programming JavaScript code, one of the authors has developed a user interface running in the web browser which exports the JSXGraph code, and that tool will be described in section *JSXGraph visual creator*.

JSXGraph constructions can also be included in ebooks based on the file format epub3. Together with MathJax (http://mathjax.org) for typesetting of mathematical formulae this paves the road to truly interactive mathematical e-textbooks.

JSXGraph Example

We close this section with a detailed example of how to use JSXGraph in a web page. It contains the well-known Euler line of a triangle. In 1765 Euler showed that in any triangle, the orthocentre, circumcenter and centroid are collinear.



Picture 1: Euler line of a triangle

The HTML <head>. First of all, in order to use JSXGraph, the JavaScript library must be included in the HTML file. Additionally, it is advisable to include a small CSS file jsxgraph.css. If loading speed is an issue, the content of the CSS file `jsxgraph.css` can also be pasted directly into the HTML file.

```
<html><head><title>Euler line with JSXGraph</title>

<link rel="stylesheet" type="text/css" href="http://jsxgraph.uni-bayreu
th.de/distrib/jsxgraph.css" />

<script type="text/javascript" src="http://jsxgraph.uni-bayreuth.de/lat
est/jsxgraphcore.js"></script></head>
```

Using an HTML element for JSXGraph. In the body part of the HTML one empty HTML object must be reserved for JSXGraph. It is recommended to set the CSS class of this element to jxgbox and to provide a width and height for this element by setting the CSS properties. In the JavaScript part of the code, this element is linked to the JSXGraph code by the `initBoard()` method. The object `board` can be used in the sequel as a construction panel.

```
<body>    ...<div id='box_euler_line' class='jxgbox' style='width:600px
; height:600px;'></div>...

<script type='text/javascript'> var board = JXG.JSXGraph.initBoard('box
_euler_line', { boundingbox: [-1.5,2, 1.5, -1], keepaspectratio:true })
;</script></body>
```

Creating geometric elements. Now we can use our board object to construct new elements via `board.create()` commands. The available geometric elements are documented at http://jsxgraph.uni-bayreuth.de/docs. For example, the triangle for which the Euler line is constructed is created by the following commands.

```
// Triangle ABC
var A = board.create('point', [1, 0]), B = board.create('point', [-1, 0
]), C = board.create('point', [0.2, 1.5]), pol = board.create('polygon'
,[A,B,C], { fillColor: '#FFFF00', borders: { strokeWidth: 2, strokeColo
r: '#009256'} });
```

Here is the complete listing of the HTML file.

```
<html><head><title>Euler line with JSXGraph</title>

<link rel="stylesheet" type="text/css" href="http://jsxgraph.uni-bayreu
th.de/distrib/jsxgraph.css" />

<script type="text/javascript" src="http://jsxgraph.uni-bayreuth.de/lat
est/jsxgraphcore.js"></script>

</head>
```

```
<body>...<div id="box_euler_line" class='jxgbox' style='width:600px; height:600px;'></div>

<script type='text/javascript'>

JXG.Options.text.fontSize = 20;

var board = JXG.JSXGraph.initBoard('box_euler_line', { boundingbox: [-1.5, 2, 1.5, -1], keepaspectratio:true}); // Triangle ABC

var A = board.create('point', [1, 0]), B = board.create('point', [-1, 0]), C = board.create('point', [0.2, 1.5]), pol = board.create('polygon',[A,B,C], {  fillColor: '#FFFF00', borders: { strokeWidth: 2, strokeColor: '#009256'} }); // Perpendiculars and orthocenter i1

var pABC = board.create('perpendicular', [pol.borders[0], C]), pBCA = board.create('perpendicular', [pol.borders[1], A]), pCAB = board.create('perpendicular', [pol.borders[2], B]), i1 = board.create('intersection', [pABC, pCAB, 0]);    // Midpoints of segments

var mAB = board.create('midpoint', [A, B]), mBC = board.create('midpoint', [B, C]), mCA = board.create('midpoint', [C, A]); // Line bisectors and centroid i2

var ma = board.create('segment', [mBC, A]), mb = board.create('segment', [mCA, B]), mc = board.create('segment', [mAB, C]), i2 = board.create('intersection', [ma, mc, 0]); // Circumcircle and circum center

var c = board.create('circumcircle', [A, B, C], { strokeColor: '#000000', dash: 3, strokeWidth: 1, center: { name: 'i_3', withlabel:true, visible: true } }); // Euler line

var euler = board.create('line', [i1, i2], {dash:1, strokeWidth: 2, strokeColor:'#901B77' });

</script></body></html>
```


JessieCode

JessieCode is a scripting language developed to describe JSXGraph constructions. It uses datatypes and syntax very similar to JavaScript and integrates the JSXGraph API into the language.

```
p = point(0,1); q = point (-1,-2); li = line(p,q);
```

The equivalent JSXGraph code is

```
var board = JXG.JSXGraph.initBoard('jxgbox'), p = board.create('point', [0,1]), q = board.create('point', [1,-2]), li = board.create('line', [p,q]);
```

The intended use is for environments where JavaScript poses a security risk in the form of Cross Site Scripting (XSS) attacks, e.g. a website with user-contributed content like a discussion board or a wiki. To allow advanced constructions, some kind of scripting is required. There are approaches that deal with the issue by securing the host site from third-party content, but a solution that is easier to set up and maintain is preferable. Another approach, filtering JavaScript with regular expressions, is not feasible. This is valid JavaScript showing cookies in an alert box (equivalent to `alert(document.cookie)`):

```
($=[$=[]][(__=!$+$)    [_=-~-~-~$]+({}+$)[_/_]+    ($$=($_=!''+$)[_/_]
+$_[+$])])()[__[_/_]+__    [_+~$]+$_[_]+$$](document.cookie)
```

Hence, instead of trying to filter out certain JavaScript patterns, JessieCode is used to control access to the DOM. This is done by preventing access to the document and window object, reducing the properties that can be accessed on objects, and filtering HTML from text elements.

Comments: Only full line comments are allowed.

```
// this is a comment point(1, 1);
```

Datatypes: The language uses the JavaScript datatypes number, string, object, function, and null. Numbers are, as in JavaScript, a mix of floating point and integers, string constants, though, may be given only within single quotations mainly. Functions can be defined by function expressions only.


```
f = function (x) { return x*3; }
```

Objects can be defined by object literal notation. Instead of curly brackets, JessieCode uses pairs of inequality signs.

```
o = << stringprop: 'hey, it\'s a string', numberprop: 42, method: funct
ion (x) { return x+x; }, sub: << subprop: true >> >>; // access propert
ies

str = o.stringprop;
bool = o.sub.true; // set properties
o.numberprop = 23;
y = o.method(2); // call methods
```

Operators and control structures: The arithmetic operators +, -, *, /, % can be used to calculate with numbers and arrays; the + operator is used to concatenate strings. Increment and decrement as well as bitwise operators are not available. Moreover, the ^ is used to express exponentiation. Logical and comparison operators behave like their counterparts in JavaScript; the latter have been extended by the = operator to compare floating point values with the precision given in `JXG.eps`.

With the exception of `switch`, which is not available in JessieCode, control structures are identical to those in JavaScript.

$board: The `$board` object is used to access the board object. It can be used to set the view or force an update.

```
// equivalent to $board.setBoundingBox([1, 2, 3, -4]);
$board.setView([1, 2, 3, -4]);
```

Element creators: Creating elements in JSXGraph always involves the `board.create()` method. The first parameter of this method is the type of element we want to create; the second parameter is an array of parent elements, like coordinates for a point, or points for a line or a function for a plot. The third parameter describes the visual appearance of that element, e.g. color and visibility. In JessieCode for every element type there is a function that takes the contents of the parent array for its parameters. With this approach, we get rid of considerable overhead and thus make constructions much more readable.

```
p = point(0,1);
q = point (-1,-2);
li = line(p, q);
```

The function call may be followed by objects containing attributes: see *Datatypes*. The attribute objects can be combined in the form of a list, where the last appearance of an attribute defines the value.

```
p = point(0,1) << fillColor: 'blue' >>;
blue = << fillColor: 'blue' >>;
thick = << strokeWidth: 8 >>;
q = point(1, 1) blue;
r = point(3, 4) blue, thick;
```

The Euler line example in JavaScript from above translated to JessieCode:

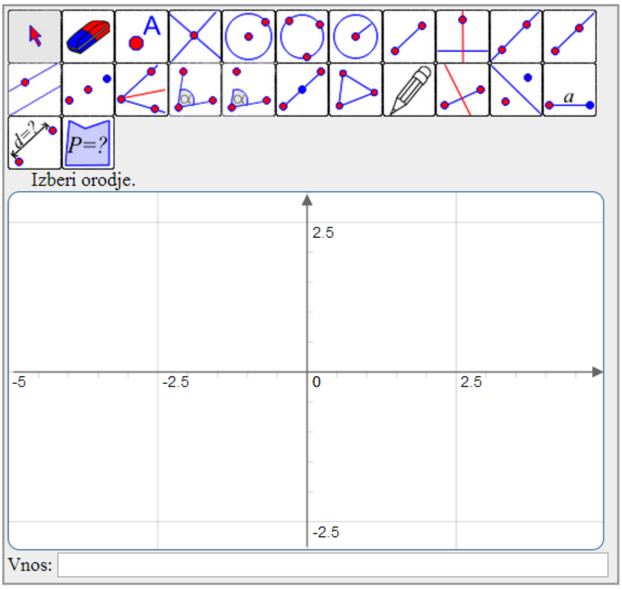
```
<html><head><title>Euler line with JSXGraph</title>

<link rel="stylesheet" type="text/css" href="http://jsxgraph.uni-bayreu
th.de/distrib/jsxgraph.css" />

<script type="text/javascript" src="http://jsxgraph.uni-bayreuth.de/lat
est/jsxgraphcore.js"></script></head><body>

<script type='text/jessiecode'>

$board.setView([-1.5, 2, 1.5, -1]); // Triangle

ABCA = point(1, 0); B = point(-1, 0); C = point(0.2, 1.5);

pol = polygon(A,B,C) << fillColor: '#FFFF00', borders: << strokeWidth:
2, strokeColor: '#009256' >> >>; // Perpendiculars and orthocenter

i1pABC = perpendicular(pol.borders[0], C);

pBCA = perpendicular(pol.borders[1], A);

pCAB = perpendicular(pol.borders[2], B);

i1 = intersection(pABC, pCAB, 0); // Midpoints of segments

mAB = midpoint(A, B); mBC = midpoint(B, C); mCA = midpoint(C, A); // Li
ne bisectors and centroid

i2ma = segment(mBC, A); mb = segment(mCA, B); mc = segment(mAB, C);

i2 = intersection(ma, mc, 0); // Circum circle and circum

centerc = circumcircle(A, B, C) << strokeColor: '#000000', dash: 3, str
okeWidth: 1, center: << name: 'i_3', withlabel:true, visible: true  >>
>>; // Euler line

euler = line(i1, i2) << dash:1, strokeWidth: 2, strokeColor:'#901B77' >
>;

</script></body></html>
```


Authoring tools

Many different authoring tools for e-learning systems are described in the literature, but a common feature of all is that they need to simplify the task of creating e-learning systems and to allow authors who are not programmers to create all parts of a system (Ritter and Blessing, 1998). An authoring tool is usually a software package with a web user interface built by pre-programmed elements which allows creation and manipulation with multimedia elements. JSXGraph authoring tools must allow a non-programmer to easily create JavaScript applets using JSXGraph library. According to functionality, developed JSXGraph authoring tools can be separated into two groups: Graphic user interface (GUI) for JSXGraph constructions and automatic code generators from given templates.

Graphic user interface (GUI) for JSXGraph

GUI for JSXGraph is implemented as a JavaScript class (called JSXGraph_GUI) and can be found on http://www.drakulic.rs/JSXGraph_GUI. An instance of JSXGraph GUI is a JavaScript applet comprising three components: a toolbox, a drawing area and a command line (Picture 2).



Picture 2: JSXGraph GUI

Initialization of GUI

GUI can be created by calling JSXGraph_GUI constructor with two arguments: the first is the ID property of the DOM element (usually div) for the drawing area, and the second is a Boolean variable which determines visibility of the axes.

```
<div id="draw_area"></div>

<script type="text/javascript">
var gui = new JSXGraph_GUI("draw_area", true);</script>
```

GUI offers considerable functionality in terms of popular systems for dynamic geometry: e.g., animation of elements in construction, automatic attaching points to nearby objects and fixing objects. The mechanism for automatic attaching points is triggered when users try to create a point, and it uses the GUI property `magnetSize` as follows:

– If there is an element with a distance less than `magnetSize` value, then:

  d. If the element is a point, a new point will not be created,

  e. If the element is a JXG.GeometryElement (http://jsxgraph.uni-bayreuth.de/docs/symbols/JXG.GeometryElement.html), a glider attached to that element will be created.

– Otherwise, the point will be created.

Setup of the GUI

After creation, GUI has the following default values:

– `boundingBox:[-x/10, y/10, x/10, -y/10]`, where the x is width of the DOM element for a board, and `y` its height.

– `snapToGrid`:`true, snapSizeX:1, snapSizeY:1`

– `magnetSize:`1.

The property `snapToGrid` cannot be turned off, but others can be changed with the following code:

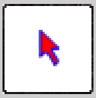
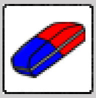
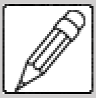
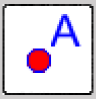
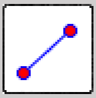
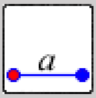
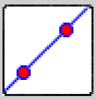
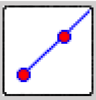
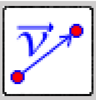
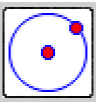
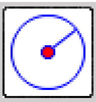
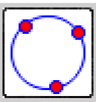
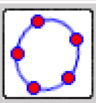
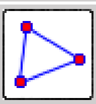
```
gui.snapSizeX = 0.5;
gui.snapSizeY = 0.5;
gui.magnetSize = 0.5;
```

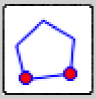
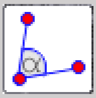
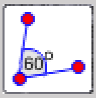
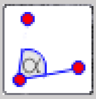
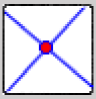
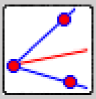
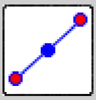
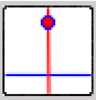
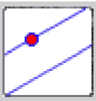
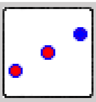
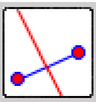
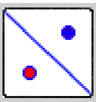
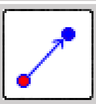
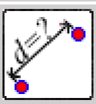
Other board properties (http://jsxgraph.uni-bayreuth.de/docs/symbols/JXG.Board.html) could be changed by changing the properties and calling methods and making change on the GUI object board: e.g. method `setBoundingBox` for adjustment property `boundingBox`.

```
gui.board.setBoundingBox([-10,10,10,-10]);
```

Adding commands in GUI

After initialization, the user needs to add commands to GUI. Currently, 30 commands are supported, and most JSXGraph Euclidian geometric elements are included. Some functionality is new – like the pencil command and the command for calculating the area of objects. Each command has an intuitive icon and manual that appear below the toolbox when the user chooses a command. Currently, all manuals are in the Slovenian language, but new languages could be easily added with an editing language file.

Icon	Command ID	Command
	_ARROW_	Select and move an object
	_ERASE_	Erase an object
	_PENCIL_	Draw an arbitrary path
	_POINT_	Point
	_SEGMENT_	Segment between two points
	_FIXED_SEGMENT_	Segment with fixed length
	_LINE_	Line through two points
	_HLINE_	Ray through two points
	_VECTOR_	Vector
	_CIRCLE_	Circle with a center and a through point
	_CIRCLER_	Circle with a center and a given radius
	_CIRCLE3_	Circle through three points
	_CONIC5_	Conic through five points
	_POLYGON_	Polygon

	_REGULAR_POLYGON_	Regular polygon
	_ANGLE_	Angle between given points
	_ANGLEV_	Angle between given points with label in degrees
	_ANGLES_	Angle with fixed size
	_INTERSECTION_	Intersection point of two objects
	_ANGLE_BISECTOR_	Angle bisector
	_MIDPOINT_	Midpoint
	_PERPENDICULAR_	Perpendicular line
	_PARALLEL_	Parallel line
	_SYMMETRY_	Reflect point about point
	_SEGMENT_SYMMETRY_	Perpendicular bisector
	_LINE_SYMMETRY_	Line symmetry
	_TRANSLATION_	Translation
	_DISTANCE_	Distance between two points

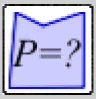
	_AREA_	Area of polygon

Table 2: JSXGraph GUI commands

Before adding commands, the user needs to create a DOM element (usually div) for the toolbox and call method `addCommands`. Arguments for this method are the ID of the toolbox element and the list of commands' IDs, as in the next example.

```
<div id="toolbox"></div>

<script type="text/javascript">
gui.addCommands("toolbox", [_ARROW_, _POINT_, _LINE_]); </script>
```

GUI has built-in support for MathJax, so labels for all constructed elements are in LaTeX.

Adding a command line

GUI has the ability to process commands from the console, but currently this functionality is weak. There is a built-in light parser that supports some basic commands – drawing lines given by implicit or explicit equations and drawing graphs of basic functions. The command line also requires a DOM element and calling function `addConsole`, as follows:


```
<div id="console"></div>

<script type="text/javascript"> gui.addConsole("console"); </script>
```

Adding elements to GUI

Users can add JSXGraph elements with the board method `create` described in section *JSXGraph*, e.g.

```
gui.board.create("point", [10, 10]);
```

By default, each added element attracts other elements with the properties described in subsection *Initialization of GUI*. This can be prevented if the element has an ID starting with "_HIDDEN_", e.g.

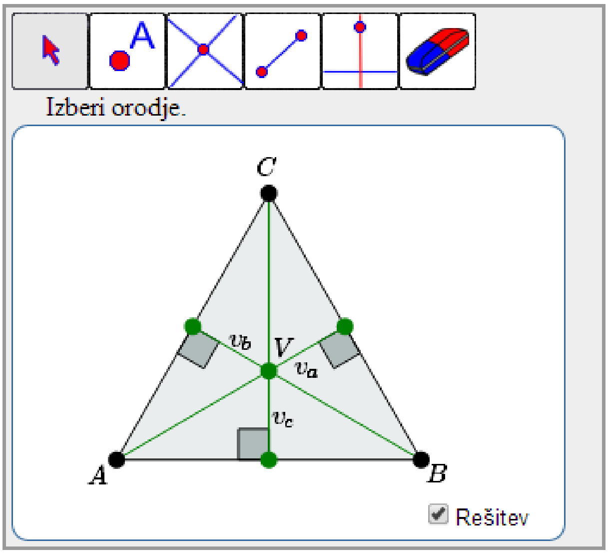
```
gui.board.create("point", [10, 10], {id:"_HIDDEN_1"});
```

Otherwise, if the element has an ID starting with "_FIXED_", it cannot be deleted, e.g.

```
gui.board.create("point", [10, 10], {id:"_FIXED_1"});
```

GUI example

This example illustrates an interactive applet for constructing the altitudes for a given equilateral triangle, with the proposed solution.



Picture 3: GUI example


```
<div style="width:340px; background:#eeeeee; border: #999999 2px solid;
">

<div id="toolbox" align="left" width="100%"></div>
<div id="box" class="jxgbox" style="width:320px; height:240px"></div>

</div>

<script type="text/javascript">

//Initialization and setup of GUI
var gui = new JSXGraph_GUI("box", false);

gui.addCommands("toolbox", [_ARROW_, _POINT_, _INTERSECTION_, _SEGMENT_
, _PERPENDICULAR_, _ERASE_]);

gui.board.setBoundingBox([-0.4, 12.84, 17.8, -0.7]);

gui.board.options.text.anchorY = 'top';

gui.magnetSize = 0.5;

//create checkbox
gui.board.create("text", [13, 0.7, '<input type="checkbox" onclick="cli
ck (this)"/>Rešitev']);
```

```
//Given triangle
var A = gui.board.create("point", [3, 2], {name:'A', label:{offset:[-17
, -2]}});

Ayy.setLabelText("$A$");

var B = gui.board.create("point", [13, 2], {name:'B', label:{offset:[3,
 -2]}});

Byy.setLabelText("$B$");

var pol = gui.board.create("regularpolygon", [A, B, 3], {vertices:{visi
ble:false}, opacity:0.1});

var C = gui.board.create("point", [polyy.vertices[2].X(), pol.vertices[
2].Y()], {name:'C', label:{offset:[-7, 22]}});

C.setLabelText("$C$");

//Proposed solution
var r = new Array();

r[0] = gui.board.create("midpoint", [Ayy, Byy], {color:'green', name:''
, visible:false, id:'_HIDDEN_0'});

r[1] = gui.board.create("midpoint", [Byy, Cyy], {color:'green', name:''
, visible:false, id:'_HIDDEN_1'});

r[2] = gui.board.create("midpoint", [Ayy, Cyy], {color:'green', name:''
, visible:false, id:'_HIDDEN_2'});

r[3] = gui.board.create("segment", [Ayy, r[1]], {color:'green', label:{
offset:[24,-10]}, name:function() { return "$v_c$" }, withlabel:true, v
isible:false, id:'_HIDDEN_3'});

r[4] = gui.board.create("segment", [Byy, r[2]], {color:'green', label:{
offset:[-45,35]}, name:function() { return "$v_b$" }, withlabel:true, v
isible:false, id:'_HIDDEN_4'});

r[5] = gui.board.create("segment", [Cyy, r[0]], {color:'green', label:{
offset:[15,-20]}, name:function() { return "$v_a$" }, withlabel:true, v
isible:false, id:'_HIDDEN_5'});

r[6] = gui.board.create("intersection", [r[4],r[5]], {color:'green', la
bel:{offset:[3,20]}, name:function() { return "$V$" }, visible:false, i
d:'_HIDDEN_6'});

r[7] = gui.board.create("angle", [Ayy, r[2], Byy], {radius:1, withlabel
:false, visible:false});

r[8] = gui.board.create("angle", [Cyy, r[0], Ayy], {radius:1, withlabel
:false, visible:false});

r[9] = gui.board.create("angle", [Ayy, r[1], Byy], {radius:1, withlabel
:false, visible:false});
```

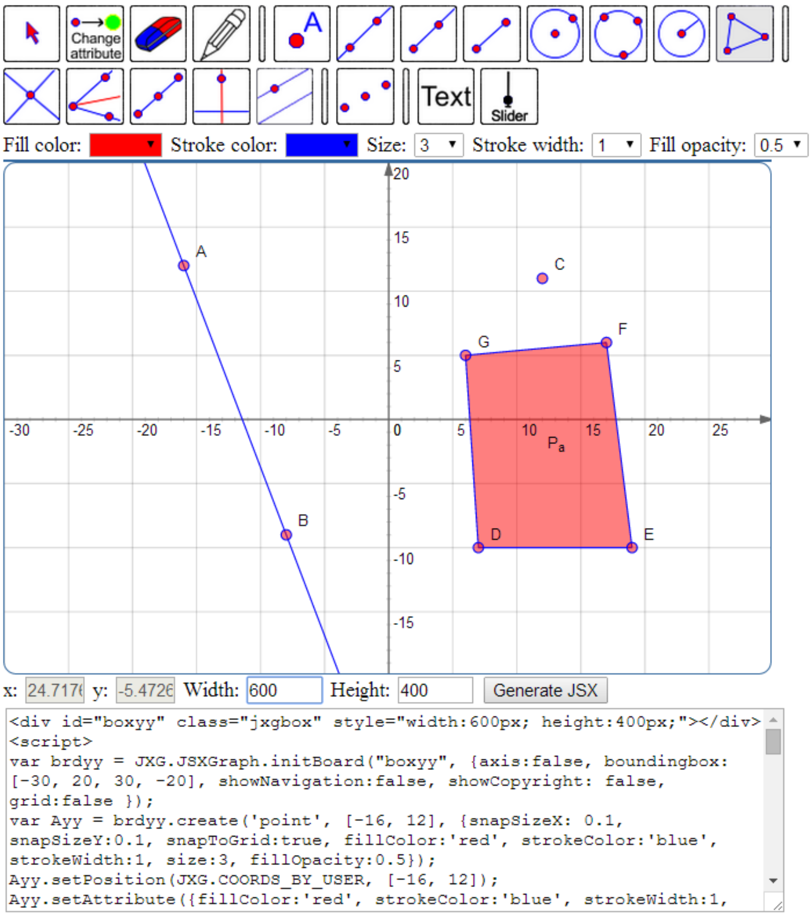
```
function click (elem) {

    if(elem.checked)
        for(var i=0; i<r.length; i++)
            r[i].showElement();
    else
        for(var i=0; i<r.length; i++)
            r[i].hideElement();

    gui.board.update();

}

</script>
```

JSXGraph code generators

As has been established, content creators can use a JSXGraph GUI as part of their applets. On the other hand, code generators allow authors to create whole applets with predefined properties.

JSXGraph visual creator

This code generator is based on GUI as described in the previous section. The main objective of the JSXGraph visual creator is to facilitate and accelerate the creation of JSXGraph elements. It allows authors to easily create elements and to set up their properties and then generates a code for them. Apart from this function of GUI, the visual creator includes several improvements: it allows the creation of slider element and has a panel for changing the properties of elements (fill and stroke color, size, stroke width and fill opacity). JSXGraph visual creator can be found at http://www.drakulic.rs/JSXGraph_VC.



Picture 4: JSXGraph visual creator

JSXGraph applets and i-textbooks

JSXGraph constructions are used extensively in all Slovenian i-textbooks. We have more than 3000 different JSXGraph applets for mathematics, physics and chemistry. These range from simple applets, where only a few basic elements are used, to complex applets, where multiple choices by the user are needed to reach the end of the applet.

Authors with more programming background can program applets directly. The remaining authors had at their disposal ten different templates (diagrams, puzzle, matching, etc.) where they had to input only the required parameters, and then server side scripts produced fully functional JSXGraph applets. Or, they created scenarios (sometimes using Geogebra) that our programmers then converted to JSXGraph applets.

To make integration and inclusion of applets in i-textbooks content as simple as possible, we made changes to our authoring tool eXeCute that enabled authors to include an applet in just two clicks. Because of the large number of applets, we made the rule that each programmer uses their project ID number as an identifier; so in case an error is later found in the applet, we can always ask the original programmer to fix it.

Conclusion

JSXGraph and JessieCode enable dynamic mathematics on a wide variety of devices from desktop computers to mobile devices. Small handheld devices are well suited for use in the classroom and allow the use of electronic material side by side with printed textbooks. JSXGraph and JessieCode are intended to be used by software developers and e-book authors to create interactive content for web pages and e-books. Based on these tools, the authors of this paper have developed several authoring tools that are used in the process of developing interactive textbooks in Slovenia.

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Design and implementation of the project E-textbooks

How to use an i-textbook

Alenka Lipovec, Jožef Senekovič, Samo Repolusk

This article uses a model of mathematics classes to present the conceptual features of the new i-textbooks for science and mathematics in primary and secondary education. Particular attention is given to the structure and function of the individual elements of each learning unit. We also present possible ways of using i-textbooks in the classroom regarding the extent of its inclusion in the lesson: the teacher can use the entire unit or part of it, while the student can use the guided instruction or the i-textbook completely independently. We also discuss some highlights in the instructional use of the i-textbooks that reveal the strengths and weaknesses of each form of their use in classroom settings. We focus on the expected shift in the roles of textbooks, students and teachers in the virtual environment, and present possible ways of using extracts of units (chapters or widgets) in the process of introducing new content. Finally, we describe and comment on the possible ways of using i-textbook partially at home and partially in the classroom (the traditional model of teaching, partially flipped classroom, flipped classroom). Various possibilities are discussed as regards the types of mathematical knowledge that we wish to develop. The paper concludes with an encouragement to the teachers at the new opportunities brought by i-textbooks in Slovenian school settings.

Key words: i-textbooks, e-learning materials, mathematics instruction, learning with textbooks, role shift, flipped learning, flipped classroom

Introduction

I-textbook brings new experience in the Slovenian school environment for a teacher and a student. We can leave aside some of the electronic learning materials, which are a welcome support in the teaching environment, but do not have a wide technical background as collections of worksheets, texts and examples and they can not be equated with the quality of an i-textbook. I-textbook is defined as an e-textbook, which predominantly contains i-learning elements with a high level of interactivity (Pesek, Zmazek, Antolin, Lipovec, 2013). This means that basic terms are introduced with i-learning elements with a high level of interactivity (Repolusk Zmazek, Hvala, Ivanuš Grmek, 2010). A student and a teacher use an i-textbook as a source of knowledge. Knowledge cannot be defined unambiguously (Rutar Ilc, 2003, p. 13), we have to know facts, terms, skills, procedures, use them in a new context and situations, integrate knowledge within one area or combine different knowledge areas. In the field of mathematics we give focus to understanding, which is defined by the quantity and quality of relationships between concepts in a cognitive scheme (Van de Walle, 2004). An i-textbook is designed to offer different kinds of experience, taxonomically diverse tasks and incentive to (systematic) an integration of knowledge (Rutar Ilc, 2003, p. 99), which enables development of processing goals; it encourages reasoning, explaining, arrangements, etc.

An i-textbook offers a lot of options for use inside and outside of a classroom, is easily accessible and can function with or without an internet connection. The purpose of application dictates the manner of i-textbook use. If an i-textbook is used by a teacher or if it is used by a student, some differences occur in the way of use. Below we will present a specific use of an i-textbook in class and an idea of i-textbook use at home (or anywhere outside of a class).

I-textbook unit

An i-textbook must cover all goals set by the curriculum (Žakelj et al, 2011). It has to enable a development of strategic and conceptual/relational knowledge. A teacher must follow the curriculum and know the concept of i-textbook use. To use an i-textbook, a teacher must examine a specific content set or at least a specific learning unit that he wants to teach with the use of an i-textbook. A teacher must inspect the goals set in a specific unit or a set, because the concept of content distribution may differ from the one used by the teacher. A teacher must also check if an i-textbook contains knowledge that students have not yet mastered or an integration of knowledge and development of problem-solving knowledge, e.g., skills that are useful in many different situations. An i-textbook for a specific class is designed linearly, but the curriculum in a spiral: each next class builds new contents based on known topics from previous classes. Students revise and consolidate known facts, concepts, properties and procedures and then upgrade an existing knowledge network with new experiences and new knowledge. The basic elements of an i-textbook are student centred activities. Students implement these activities directly with an i-textbook (applets, demonstrations, spreadsheets, images) or in their own environment (working with material, pictures and sketches in a notebook, observing phenomena, monitoring of events, browsing the Internet, use of ICT, etc.) These activities are in the function of acquiring and expending knowledge of a known concept (Jurman, 1999). Mathematical terms are rarely presented trough prototypes; they are mostly presented trough several well-chosen examples and counterexamples. Technology also enables introduction through encapsulation, where a term, as an object, develops through a process of activities (Tall, 2000). A student learns and forms a term in his own mental scheme trough a specific activity. With examples that support the scope of a concept, students integrate knowledge from various areas of mathematics and build familiarity and understanding of a concept. They use hints, images, animations and solutions. The introduction page of a unit (1 to 3 lessons) motivates a student with an applet or any other activity to think about the content and required knowledge for a specific e-learning unit. This introductory activity implicitly sets an essential question (Rutar Ilc, 2003, p. 57), which motivates students to start thinking about the topic. A student is an active participant while a teacher supports him by planning and implementing the school process.

Let us take a look at the following example of combinatorial situations in 7th grade of primary school (http://eucbeniki.sio.si/test/iucbeniki/ma7/780/index.html, p. 454) indented for 2 lessons. A primary school curriculum (Žakelj et al, 2011), in its context of mathematical problems and problems related to real life situations, includes the following goals, which directly affect development of knowledge in combinatorics and are realized in this specific unit: students research combinatorial situations, learn and use a combinatorial tree, solve a combinatorial problem on a graphical level (solve and display a solution with an image, sketch, spreadsheet, combinatorial tree), solve a combinatorial problem on a symbolic level (setting up a calculation), generalize a solution for a combinatorial problem (also with examples), solve combinatorial problems related to real life situations (restaurant menu composition, assembly of furniture from different parts). A student must meet two standards by the end of the third third-cycle: solve a combinatorial problem and show a solution and use mathematics with real life problem solving. Minimum standard at the end of 7th grade is: solve a mathematical problem and a problem related to real life.

A selected unit of an i-textbook (Figure 1, left side) shows an introductory activity, which motivates students to think about arrangements and solving an essential question:

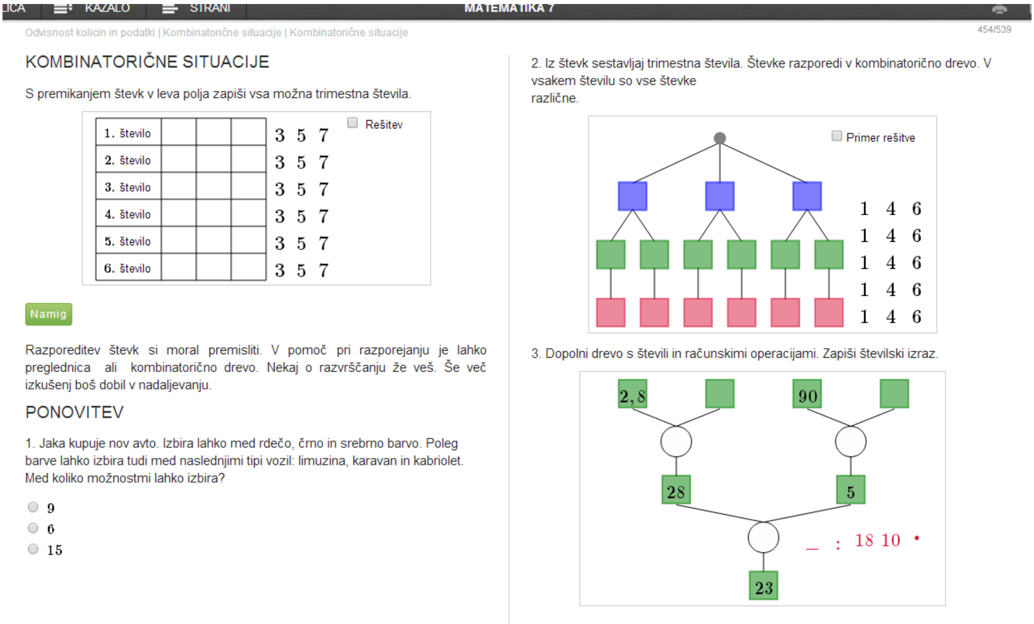


Figure 1: Introductory activity (Source: http://eucbeniki.sio.si/test/iucbeniki/ma7/780/index.html)

Students are asked to distribute digits 1, 2 and 3 in a number. They need to know a place value notation of numbers is important. Students independently arrange digits and think about a number arrangement, which can not be repeated in any step. They may try solving this problem by guessing (unsystematic), by comparing size of written numbers or with a systematic arrangement of digits in specific places. They may start with an optional arrangement of numbers or with the offered number 357. If the solutions are correct, students get positive feedback and get a chance to review possible numbers in the offered solution.

With a comment placed below a spreadsheet, we remind students that they have already met with number arrangements. They created arrangements with the help of a spreadsheet and a combinatorial tree (6th grade, Combinatorial situations, http://eucbeniki.sio.si/test/iucbeniki/ma6/1238/index.html). In next three examples they repeat the use of recording possibilities in a combinatorial tree (Figure 1, right, 2nd exercise) and the use of a combinatorial tree to display the implementation order of arithmetic calculations (Figure 1, right, 3rd exercise). Students know the basics of combinatorial situations. They encountered simple examples of using the fundamental theorem of combinatorics, permutations, combinations and variations in the 5th grade (http://eucbeniki.sio.si/test/iucbeniki/mat5/1212/index.html).

With a repetition in the introduction and motivation section, we direct students to further reflect and gain new experience in combinatorics. An essential question is indicated: what else can we learn about combinatorial situations? We continue our work with a specific example on page 455 (Figure 2).

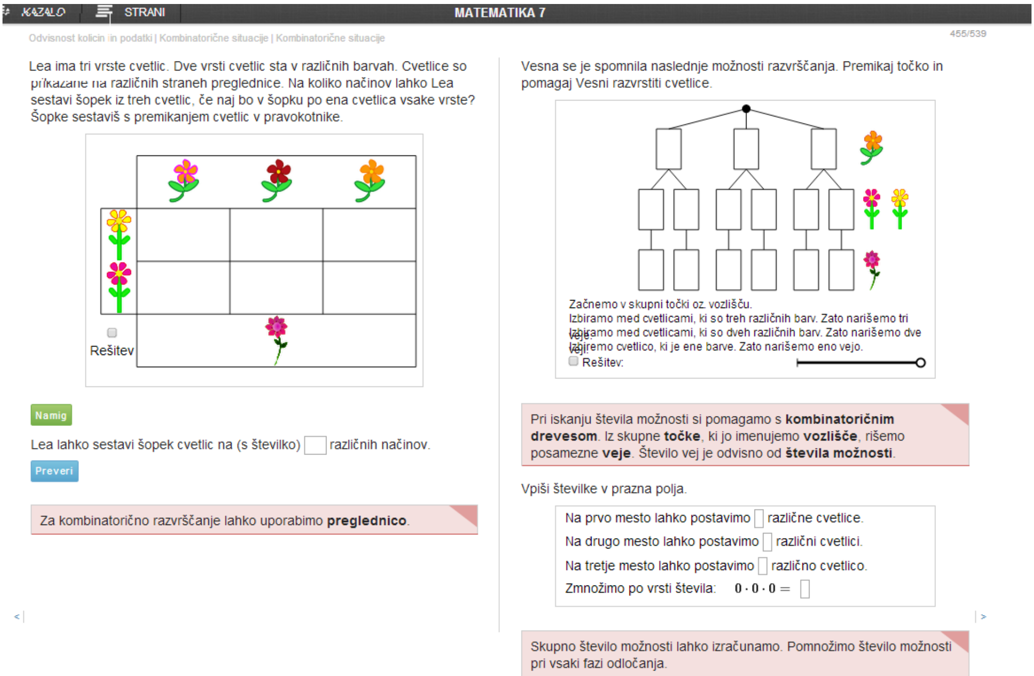


Figure 2: Arrangements (Source: http://eucbeniki.sio.si/test/iucbeniki/ma7/780/index1.html)

With a demonstration (applet) on the left side (Figure 2) we motivate the students to arrange flowers. Since there are three kinds of flowers (one in three colours, second in two colours and the third in one colour) students learn from instructions, that each bouquet must include three different flowers. As a result we form 6 different bouquets. If a student is unsure of how to complete this exercise he can use a Hint (assembly of a bouquet can be addressed systematically): In the first bouquet (first field) you drag the flower from the left, up and below. You get a bouquet with three different species and three different colours of flowers. In the next field you again drag a flower from the left, up and below. This bouquet is different from the first one because of a flower from the upper row. (Continue on your own.)

On the right side of the unit (Figure 2) students continue with their activity. They solve the same exercise with a combinatorial tree. Both exercises motivate students to autonomous thinking about a number of different kinds of bouquets. This is a question about number of different arrangements. With a direct comparison of the two arranging methods, students gain experience, which they can use in new situations. The same problem is presented in two different ways. This activity leads a student to a conclusion that helps him calculate the number of all arrangements. The number of all possibilities is a result of arrangements in each decision-making stage, which presents a third kind of presentation (arithmetic presentation).

On the page 456 (Figure 3) students consolidate their new gained knowledge in new situations.

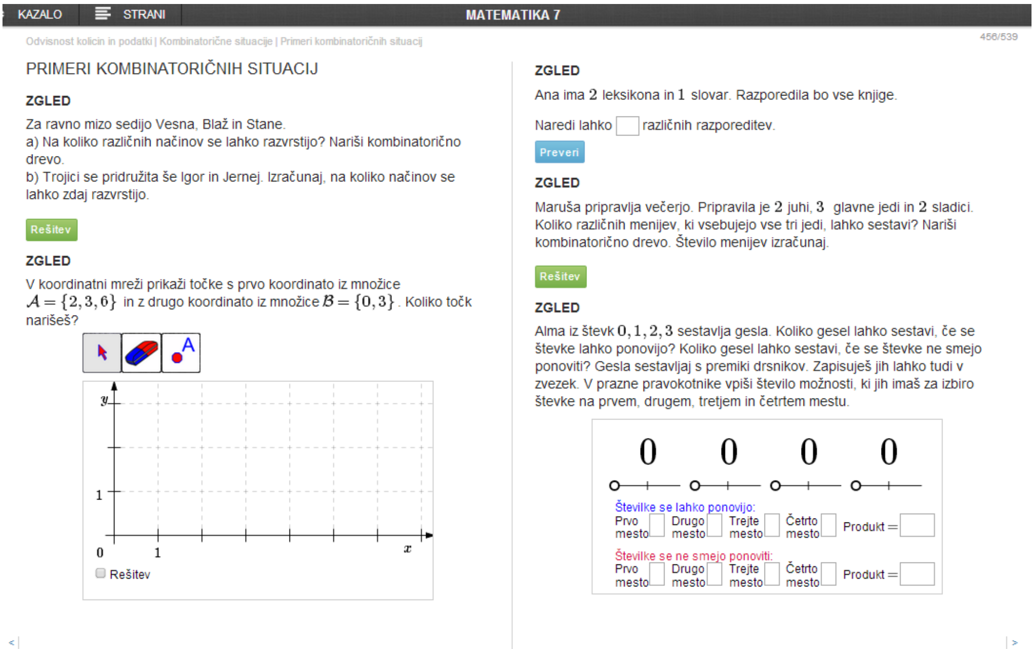
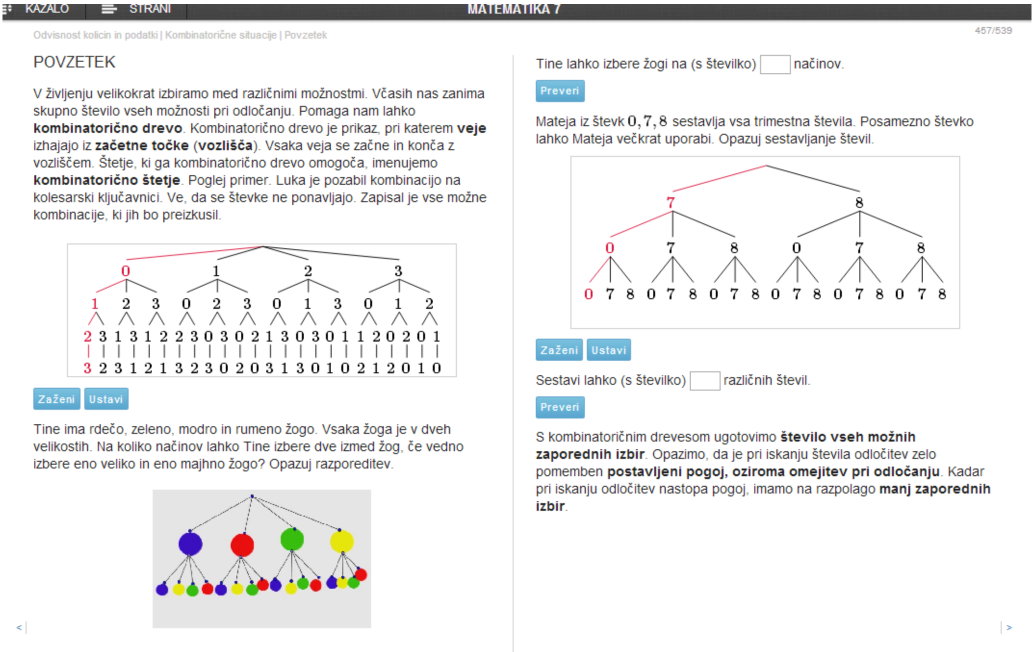


Figure 3: Further examples (Source: http://eucbeniki.sio.si/test/iucbeniki/ma7/780/index2.html)

The first example demonstrates the use of a combinatorial tree in seating arrangements. Three different persons can be seated on the first seat. When the first seat is filled, only two more persons can be seated on the second seat, which leaves only 1 person to be seated on the third seat. This again gives us 6 different possible arrangements. On the right, we can see an example of investigating different options with repeating digits and without repeating digits.

We complete this content with an Abstract on page 457 (Figure 4), where we summarize essential knowledge, novelties, procedures, definitions and formulas.


KAZALO STRANI MATEMATIKA 7

Odvisnost količin in podatki | Kombinatorične situacije | Povzetek 457/539

POVZETEK

V življenju velikokrat izbiramo med različnimi možnostmi. Včasih nas zanima skupno število vseh možnosti pri odločanju. Pomaga nam lahko **kombinatorično drevo**. Kombinatorično drevo je prikaz, pri katerem **veje** izhajajo iz **začetne točke (vozlišča)**. Vsaka veja se začne in konča z vozliščem. Štetje, ki ga kombinatorično drevo omogoča, imenujemo **kombinatorično štetje**. Poglej primer. Luka je pozabil kombinacijo na kolesarski ključavnici. Ve, da se števke ne ponavljajo. Zapisal je vse možne kombinacije, ki jih bo preizkusil.

Zaženi Ustavi

Tine ima rdečo, zeleno, modro in rumeno žogo. Vsaka žoga je v dveh velikostih. Na koliko načinov lahko Tine izbere dve izmed žog, če vedno izbere eno veliko in eno majhno žogo? Opazuj razporeditev.

Tine lahko izbere žogi na (s številko) ____ načinov.

Preveri

Mateja iz števk $0, 7, 8$ sestavlja vsa trimestna števila. Posamezno števko lahko Mateja večkrat uporabi. Opazuj sestavljanje števil.

Zaženi Ustavi

Sestavi lahko (s številko) ____ različnih števil.

Preveri

S kombinatoričnim drevesom ugotovimo **število vseh možnih zaporednih izbir**. Opazimo, da je pri iskanju števila odločitev zelo pomemben **postavljeni pogoj, oziroma omejitev pri odločanju**. Kadar pri iskanju odločitev nastopa pogoj, imamo na razpolago **manj zaporednih izbir**.

Figure 4: Abstract (Source: http://eucbeniki.sio.si/test/iucbeniki/ma7/780/index3.html)

An abstract contains a summary of new gained knowledge, which is usually accompanied with specific examples or questions that cover the entire unit. The selected unit, Combinatorial situations, includes a repetition of terms and a demonstrations of combinatorial tree arrangements with and without repetition.

An abstract is followed by a series of differentiated exercises (Figure 5). Green exercises are less difficult, but taxonomically different. These exercises should help students consolidate knowledge, terms and the use of knowledge (to a certain point) in known situations.

Blue exercises (Figure 6) are a bit more difficult. Students require good knowledge of basic terms, integration of knowledge, procedures, different representations, logical reasoning and deduction.

Red exercises (Figure 7) are more demanding and require an adoption of content and procedure knowledge on a high level. It demands a lot of reasoning, judgement and complex decisions.

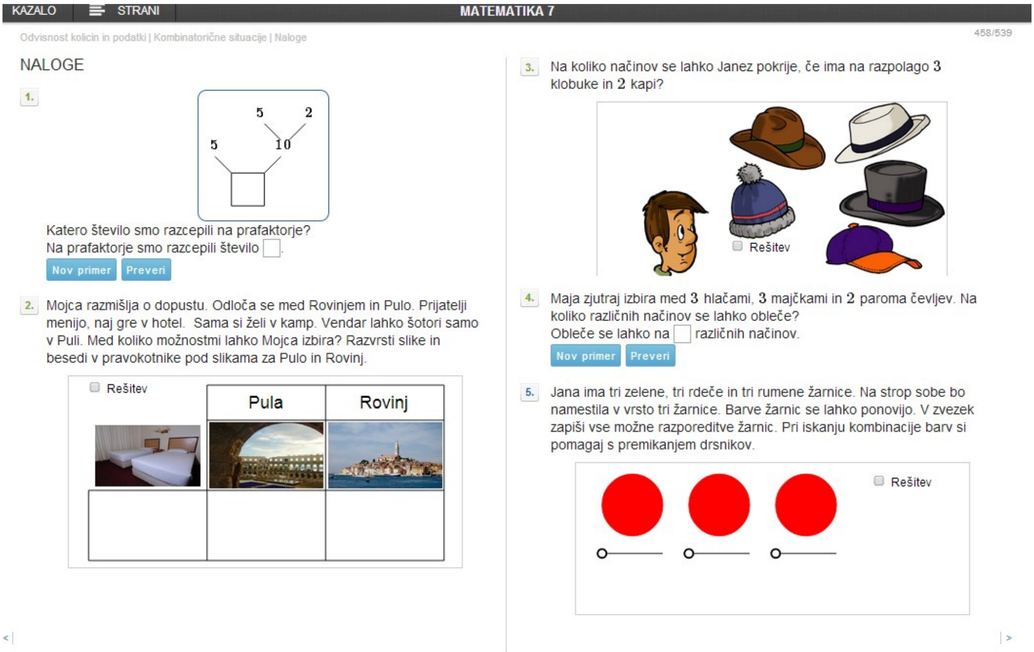


Figure 5: Exercises (Source: http://eucbeniki.sio.si/test/iucbeniki/ma7/780/index3.html)

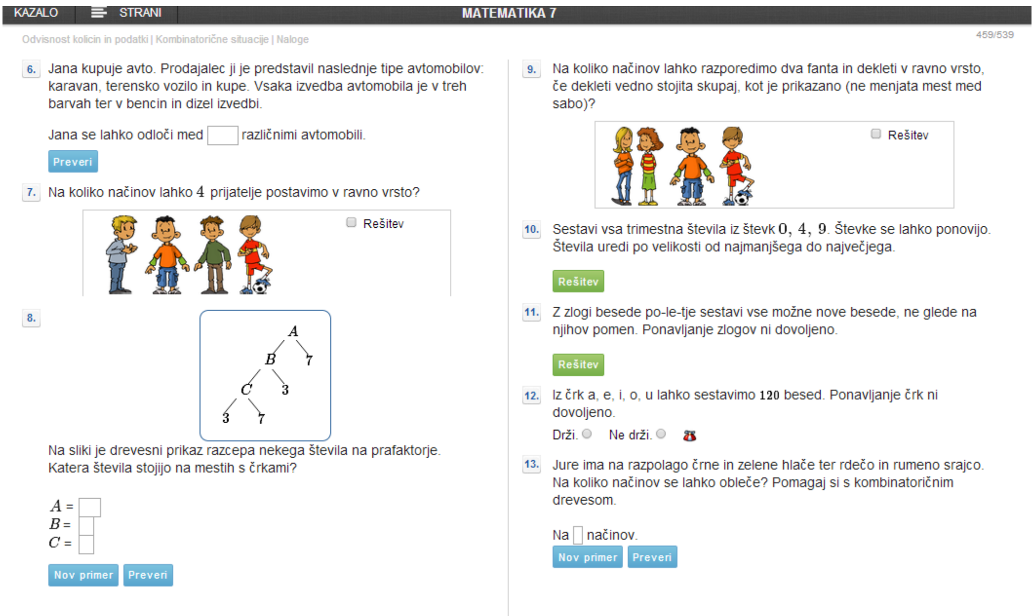


Figure 6: Exercise differentiation using colour marks (Source: http://eucbeniki.sio.si/test/iucbeniki/ma7/780/index5.html)

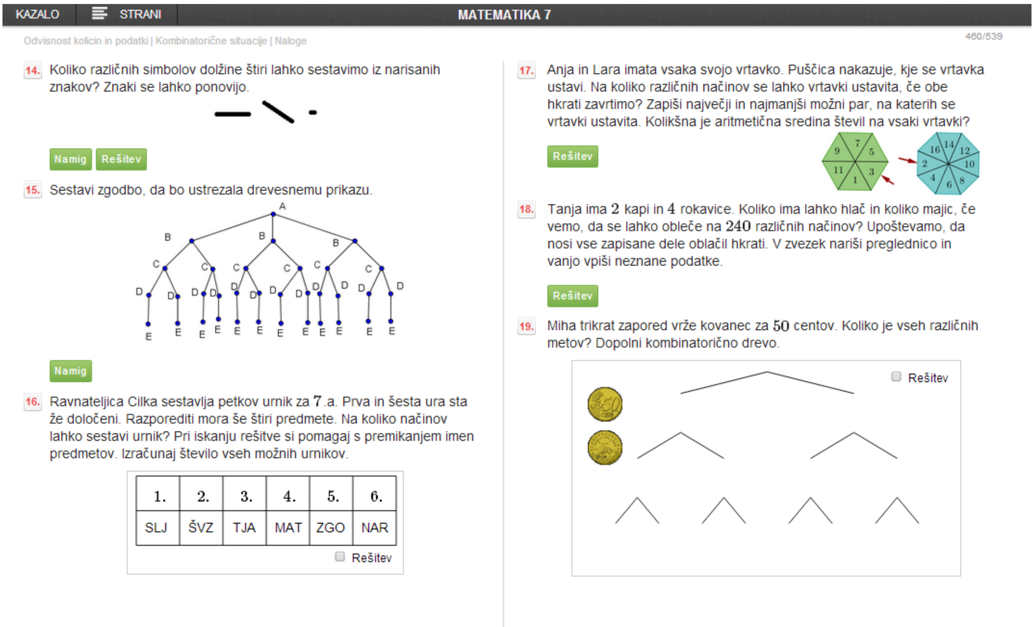


Figure 7: Difficult exercises (Source: http://eucbeniki.sio.si/test/iucbeniki/ma7/780/index6.html)

It is not necessary for a teacher to solve all the exercises before using an i-textbook. But he must test if an applet functions properly and how to include it in the teaching process. The structure of specific units in an i-textbook is uniform, which enables a transparent, systematic and predictable monitoring of learning steps in knowledge acquisition for teachers and students.

In the following segment we will present some examples of i-textbook use in mathematics class, considering the extent of unit's involvement in content.

Teacher uses the whole i-textbook unit

The Combinatorial situations unit is set for 2 lessons. We can not expect students to be motivated for an independent use of an i-textbook if we only tell them to read the text, examine the examples and study elements shown. Reading instructions and text is usually only superficial, because students often skip parts they have no interest in. They click trough interactive elements (test their function) and do not think about them as teachers would want them too. That is why students need guidance with the use of an i-textbook (Uesaka and Manalo, 2008). They can receive verbal step by step instructions, but the danger of verbal instructions is in the fact that students do not always focus on what a teacher is saying and often overhear essential information, which is why a teacher can give written instructions. This next example will show guidance with the help of a work sheet (Annex). A worksheet can be a component of a specific i-textbook unit and is prepared by the teacher himself. It can be stored in a digital form in an e-classroom so there is no need for copying. Students can take notes into their own workbook, notebook or in a document on a computer. We can also prepare online instructions (e.g., with the eXeCute tool) and monitor students progress. Instructions must be short, comprehensible, structured and unambiguous. At the same time, we must allow a student to complete required assignments in his own tempo, examine examples, take notes and solve exercises (individualisation).

In the introduction we encourage a student and motivate him to use an i-textbook. Let us take a look at the following example from a worksheet (annex):

Follow the instructions in this i-textbook. Think about the problem, consult with a schoolmate or a teacher and only then look at the solutions. Use Hints.

Write the title in your workbook.

Page 454 (Combinatorial situations)

a. Complete the first exercise by arranging digits 3, 5 and 7 into three-digit numbers. Read and consider all the text in the section before the title Repetition.

Write down all numbers from exercise 1:

b. Complete the exercises 1, 2 and 3 from Repetition.

Write down the maximum and minimum number from exercise 2:

Write down the resulting numeric expression from exercise 3:

What do we call a systematic arrangement of digits? Circle the correct choice.

A Copying **B** Combining **C** Guessing **D** Repeating

In the first step students complete a motivational task and refresh their memory on combinatorial arrangements by solving exercises from the Repetition section (1, 2 and 3). Taking notes in a workbook/notebook requires focus, writing down all reflections and findings. Of course a student can simply copy all three-digit numbers, but the same can happen in a classical teaching lesson, when a student simply copies from the whiteboard and does not solve or think about the problem.

Let us continue our work with a worksheet:

Page 455 (Combinatorial situations)

a. Read the instructions from the first exercise (flowers). You can use the Hint button before you solve this exercise. Fill in the gaps below the spreadsheet.

b. Read instructions on the right. Drag the display point and arrange the flowers.

How can we display combinatorial arrangements? Circle the correct choice.

A In a line **B** In a spreadsheet **C** In a cube **D** With a combinatorial tree

Students know we can display combinatorial arrangements with a spreadsheet or a combinatorial tree. This is why they use their own experience and solve some exercises. The questions on a worksheet do not have to be identical to the ones in an i-textbook (efficiency, emphasis on different things), but modified to monitor student's comprehension of content. Comprehension is a process of internalization; when a student reads a text he translates it into an understandable message that corresponds to the concept of existing knowledge (Rutar Ilc, 2003, p. 60). Active thinking on various perspectives and setting questions a student must find answers to, enable learning with comprehension (e.g., worksheet - Annex):

Complete exercise 2, 3 and 4 (page 458, Exercises). Answer the questions.

Exercise 2: What are the odds of Mojca staying in Rovinj for the summer? ____________

Exercise 3: How many choices does Janez have if he can choose between 1 hat and two caps? ___________

Exercise 4: Simona is picking out an outfit. She has a choice of 3 pants, 3 t-shirts and 2 pairs of shoes. How many different outfits can she wear? ________

Students then write down (in a notebook, a file on a computer, online instructions) important facts that summarize main findings:

We can use **a spreadsheet** or **a combinatorial tree** for combinatorial arrangements. The total number of possibilities is calculated **by multiplying all the possibilities at each stage of arrangements**.

Students then solve different exercises and gain knowledge of combinatorial arrangements (with a systematic approach to solving examples they consolidate knowledge). We can also add some additional questions to exercises, with changed data or conditions. They can write down a correct answer only if they solved the exercise by themselves. They are first introduced to a few examples of seating arrangements at a straight table, where they use strategy of combinatorial arrangements in several different situations:

Page 456 (Combinatorial situations)

a. Complete the first Example (sitting at a straight table). If you are having trouble solving it, help yourself with the solution.

   Complete exercise 6 (page 459, Exercises). How many different types of cars can Jane buy if she has these options: a pickup truck, an SUV and a caravan, a diesel, petrol or electric engine and two different colours?

   Complete exercise 9 (page 459, Exercises). In how many ways can we arrange John, Luke and Mary in a straight line, if boys always stand next to each other?

Students then solve further examples (page 456):

a. Solve second Example (plot points on a coordinate grid).
b. Solve fourth Example (Maruša is making dinner) in your notebook.
c. Solve fifth Example (Alma and passwords with digits).

Students can consult with a teacher, use hints or a solution written in the unit. When they are solving an exercise they can return to solved examples and reflect on procedures used in them. We introduce them to this kind of work with a systematic guidance from an example to an exercise and back to an example. After solving above examples, students solve these exercises:

Solve exercises on pages 458, 459, 460.

Exercise 10: Justify why we can not use digit 0 in hundreds' place.

Exercise 12: How many words (that make sense or not) can we form from letters a, t and e if they can not be repeated in the same word.

Exercise 16: 7th grade has Math on second lessons of the curriculum and PTE on third. How many different timetables can we form?

Exercise 19: You toss a coin two times in a row. Write down the odds for T-tails and H-head.

Read the summary.

The choice of exercises, number of exercises and a possible differentiation depend on goals set by the teacher. We consider students' experience and skill with computer tools (programmes). If we use written instructions this made lead to student differentiation; students progress with different speed. In this case a teacher may consult with students individually (individualisation), because there is no need for constant supervision of the entire group. Feedback is gained trough observation of worksheet completion, use of examples, additional questions, students' reports, etc.

At the end of a lesson we ask students to read the Abstract and interpret it freely in front of the entire group.

Teacher uses a part of an i-textbook unit

A teacher can also use only a part of a unit: an applet, activity or an example. A part of learning material is used for frontal teaching or in a classroom with only one computer. A teacher shows an example and directs students to reflect on the example with additional questions (heuristic approach) with special attention given to taxonomy of questions set. Maganja (2009) observes that over 80% of questions in Mathematics and second third-year are on a lower taxonomy level, with over 50% unambiguous questions. When arranging digits, a teacher can challenge students to arrange digits by themselves in a notebook. A teacher then uses an example in an i-textbook to introduce a new strategy of arranging combinations (a combinatorial tree). An additional example is usually used for justification of the solution and to help students develop mathematical language and logical reasoning.

Teacher can introduce the example of digits arrangements at the beginning of a lesson. By observing the example, students write down explanations on how the presentation functions (we use digits 1, 2 and 3, form numbers, form different orders of digits, etc.). Teacher tests students’ comprehension with a new example that includes two, three or four digits or uses other examples in an i-textbook.

A part of learning materials can be used to develop problem knowledge and for research. An example of digit arrangements into passwords (e.g., for lock combinations) can be a basis for getting a number of passwords with or without repetition for n-digits. Solving an example in school can be a motivation for mathematically more ambitious students and individual research.

A teacher can also use exercises in an i-textbook for consolidation, testing or even grading of knowledge. Difficulty of specific exercises or sets of exercises can be used for differentiation. A teacher can use an exercise generator to consolidate certain procedures. To consolidate exercises that require planning, he can use online exercises that include the use of a geometric tool. Students then solve these exercises in their notebook with classical geometric tools. With the choice of research exercises, a teacher can differentiate research based on students' abilities and thus enable development of required processing knowledge.

Independent use of an i-textbook

The design of an i-textbook offers autonomous learning. If a student is absent from school for a longer period of time (sickness, sports, travel, etc.) a student can, with guided and well planned work, conquer most of the teaching goals by himself. Even with individual work some guidance from a teacher is needed. A teacher guides and advises a student and enables goal targeted study of content. If possible, a student should not be left to himself with reading and solving an i-textbook. He should gain knowledge under written instructions given by a teacher, or at least verbal if there is no other option. This enables a planned goal targeted thinking and reasoning. In this way a student can also avoid examples and exercises that might not be in sync with a teachers concept of content processing.

In a specific example of Combinatorial situations in 7th grade, individual work resembles work in a classroom (with guidance). Hints and solutions play an important role in this, because they enable quality real time feedback on strategy of solving and the solution itself. Generated exercises on numerous numerical or graphic examples enable consolidation of knowledge and internalizing of procedures to a routine level. Independent work of a student can be rewarded by establishing communication in an e-classroom. A student can verify his knowledge by solving exercises on different levels of difficulty. It also made sense to make all i-textbooks of previous classes available to students: in 7th grade they can access a unit on combinatorial situations from 6th grade, solve some exercises and refresh their knowledge.

Emphasis in use of an i-textbook

There are some advantages and disadvantages of i-textbook use.

A teacher that uses the entire material of a specific unit is bound to examples, knowledge and exercises included in that i-textbook. The concept of his teaching must me consistent with the content context of the i-textbook. All steps must be carefully planned; which examples, exercises and activities will be used. He must also consider which exercises will be used to consolidate new knowledge and the type of knowledge that will be developed in a unit. Only a well planned and purposeful teaching with an i-textbook can improve the quality of knowledge. An unprepared teacher who indiscriminately or even spontaneously chooses sets of activities, examples and exercises can not expect a positive effect from the use of an i-textbook. An i-textbook is in such cases purely and simply a technological "spice up" for the students. It makes sense that teaching with an i-textbook takes place in a computer classroom or with tablets, where every student has a chance to work independently. This enables a high degree of individualisation of learning paths. Although there may be a case where some uncritical and leisurely students will, in the initial period, without consideration or effort just look at the solution. However, to develop a mature and responsible student with the ability of self-regulation is one of the process goals of each lesson, so we need to give students an opportunity and time to mature. A school must also provide appropriate technical support and functioning of equipment. This form of teaching must provide students with clear instructions for work to allow individual progression. Teacher may, however, focus on individual students and provide differentiated work both in the phase of new content acquisition and in the phase of knowledge consolidation and verification.

A teacher can only select an individual part or element of an i-textbook (applet, activity or example). After selecting each i-textbook component, a teacher includes it in his own lesson concept, which may be independent from the concept of introducing content of an i-textbook. Since some classes today still take place in classrooms with only one computer and a projector, a teacher must be attentive of some technical features. Consideration should be given to the possibility of a bad visibility of projections, which depends on the available option of dimming the classroom and the quality of a projector. However, dimming a classroom prevents students from taking notes or solving problems in a workbook, which can be carried out only after observing a presentation. This limits the activity of students, who become observers and not creators. A teacher must take role of an activator, because the motivational effect of observation is less strong as the one of operation (independent student activities). He must therefore anticipate steps of use for a specific section of an i-textbook, his own questions, students' questions and potential problems and misunderstandings. He must also provide a high quality educational conversation for the time of an activity: communicate with students, set challenges and request solutions, explanations and written justifications. Since students do not have access to hints and solutions in an i-textbook, a teacher can limit its uncritical use (when students without effort look at the solution of an exercise).

An independent use of an i-textbook outside of school (without teacher supervision) poses a risk of superficial reading and observation of text, images, animations, presentations, etc. A student will probably just "click" trough each set: what is planned to be processed in one lessons will be "clicked" trough in few minutes. If a teacher expects or demands independent use of an i-textbook, students must first be trained for such work. The best way to achieve this objective is trough diverse demonstrations of i-textbook use at school (with detailed instructions). Training for work with an i-textbook can be carried out in shorter sets, individual help or remedial classes. We deliberated with students how we "read" and solve specific sets of knowledge: performing activities, observing, concluding, help with hints, solve in a workbook and solve exercises. Students, who will be absent for a longer time, should plan the use of an i-textbook with their teacher: what content should be read, which activities and examples completed and which exercises solved. Students should still take notes in a workbook and form some sort of a personal folder of i-textbook use (which activities were completed, which examples and exercises were solved, which issues gave them difficulties, etc.). A teacher can test the quality of knowledge with exercises in an online classroom and can use generated i-textbook exercises or issues relating to solved exercises and examples. An advantage of individual use of an i-textbook is in the repeatability of learning steps and clarity of interactive displays. An i-textbook offers direct activities (interaction), which go beyond simple observations. An activity can be stopped at any point and continued from any point. An access to i-textbooks of previous classes should also be available to long absent students. If a student encounters concepts which he already forgot (e.g., area of shapes), he can search for content and any other activities with a few clicks. This activity should also be learned with the assistance of a teacher, because only a well-prepared student will know how to take advantage of individual use of an i-textbook.

In the following section we will look at other possible examples of i-textbook use that include different kinds of mathematical knowledge, teacher-student roles and the extent of i-textbook use in school and at home.

Extent of i-textbook use in school and at home

One of the guidelines of i-textbook development is a shift in roles of a textbook and student-teacher relationship (Blažič, Ivanuš Grmek, Kramar and Strmčnik, 2003, p. 124; Engelbrecht and Harding, 2005, p. 236; Ameis, 2006, p. 19; Lau, Singh and Hwa, 2009).

A shift in the role of a textbook is seen as a deviation from the prevailing role of a textbook as a source and a substantive part of preparations for a teacher to the role of a source of activities for students. I-textbooks can, due to their interactive capabilities, in addition to the usual substantive applications, also take on some didactical functions that were reserved for didactic manuals and for teachers: an incentive to use specific methods of work (e.g., research "with the use of an applet research", discussion "consult with classmates on the findings"), real-time feedback in individual student activities, generate new exercises, a multi-sensor approach to term definition (text, image, video, sound, applets).

A shift in the role of a student is seen as a deviation in the fundamental activities of a student when using an i-textbook compared to a printed textbook: a student is primarily a reader and an observer (pictures, derivation) where with an i-textbook he takes on an active role in different interactive activities. With an increased activity of a student in the process of building knowledge, it is expected that an efficient use of an i-textbook will be, in its initial stage, less attractive for some students, especially if they are accustomed to all knowledge being brought to them "on a silver platter" and are not challenged with open questions and dilemmas that require some effort. However, such a shift enables a student to develop a sense of responsibility for an effective and sustainable building of knowledge (even in light of subsequent autonomous learning on higher education levels and in the framework of lifelong learning).

A shift in the role of a teacher is seen as a deviation from a perception of self as a key "provider" of knowledge to a role of a mentor that supports, coordinates and summarises key lesson activities for a student. Such a shift, of course, does not mean that a teacher is given a lesser role in class or even less work, but on the contrary. Each reflection on what students are capable of achieving with self directed meaningful activities (and a teacher does not need to deprive them of the satisfaction of an independent discovery), and where a teachers' mediation is required (when students need to be monitored because of abstract content, novelties or technical complexity of a concept) demands an excellent concept knowledge as well as extreme didactic flexibility, which is a lot more time and thought consuming than in a traditional approach to the method of interpretation.

These shift are not a consequence of i-textbooks themselves, but i-textbooks are, compared to a classical textbook, a textbook that offers additional supportive environment (Engelbrecht and Harding, 2005; Yerushalmy, 2005; Lau, Singh and Hwa, 2009).

Planning the use of an i-textbook according to the suitability or effectiveness in a specific part of a teaching lesson (teaching step) can be done with the use of an i-textbook in the introductory motivational and repetitive phase (Introduction and Repetition), in an introduction to a new concept with regular assessment of knowledge (Body), with summarising findings (Summary) or in the phase of consolidating and/or assessing knowledge (Exercises). An i-textbook can also be used in several parts at once or in a whole lesson, as we have already shown. Each i-textbook use is a decision made with teachers' expert judgement.

This decision making process is illustrated with an example of application of individual sections of the same e-unit Pythagorean theorem in the 8th grade of primary school. In order to achieve content objectives we decided to use the Pythagorean theorem in an 8th grade e-textbook on page 417 (source: http://eucbeniki.sio.si/test/iucbeniki/mat8/842/index.html, Last visited 6. 4. 2014). A teacher may decide to use an i-textbook as an introductory motivation, where students look for common properties of displayed objects in an album of pictures - form of a right triangle (source: http://eucbeniki.sio.si/test/iucbeniki/mat8/842/index.html, left). After an activity has been completed, a teacher can direct students to review the required knowledge by solving exercises on the right side of the aforementioned e-unit (Repetition) or he may decide to upgrade the approach in an i-textbook and asks students to find additional examples of a right triangle in everyday life on the Internet (promoting development of ICT use and finding resources in a foreign language). Further steps may be carried out by a teacher in the traditional way using a whiteboard and a notebook, or with the use of a flash e-unit. The body of a lesson is discovery and understanding of the Pythagorean theorem, where a teacher, if he so decides, has at least three options:

1. Students discover the connection between surface areas of a squares above right triangle sides with prepared activities, applets and spreadsheets in an i-textbook (source: http://eucbeniki.sio.si/test/iucbeniki/mat8/842/index2.html, left, Figure 8). In this case the main element of the Pythagorean theorem is already provided and students do not need to discover or verify it (triangle is perpendicular).
2. Students use a conceptual applet in an i-textbook (source: http://eucbeniki.sio.si/test/iucbeniki/mat8/842/index3.html, right, figure 9), but not as predicted; an applet, which has a role of verification and possible generalisation of the Pythagorean theorem for angled and obtuse triangles is used as an application to investigate where the critical condition is not set in advance (triangle is perpendicular), but is discovered by students trough steps. In this case, a teacher prepares specific instructions for activities and students use the applet without any accompanying instructions.
3. A teacher can develop an independent investigative applet for the Pythagorean theorem and include it in an e-classroom together with the corresponding instructions on a worksheet. Students then research new knowledge in the body of an i-textbook.

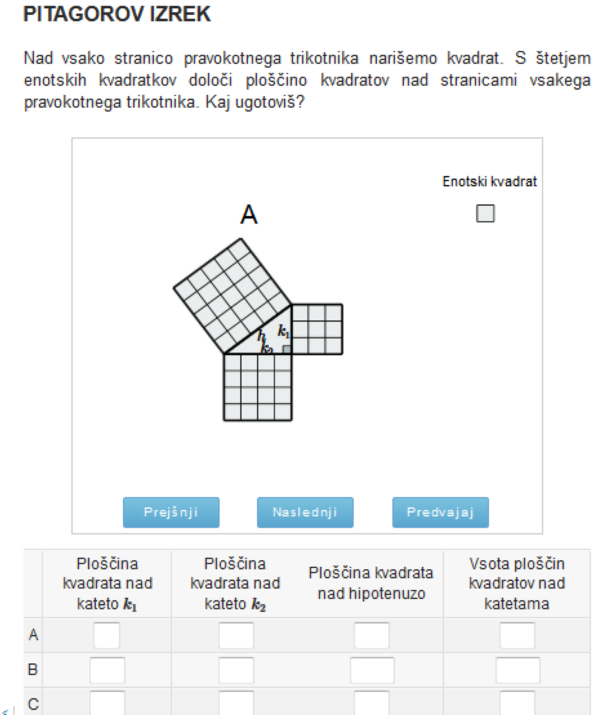


Figure 8: Discovery of the Pythagorean theorem in an i-textbook (Source: http://eucbeniki.sio.si/test/iucbeniki/mat8/842/index2.html)

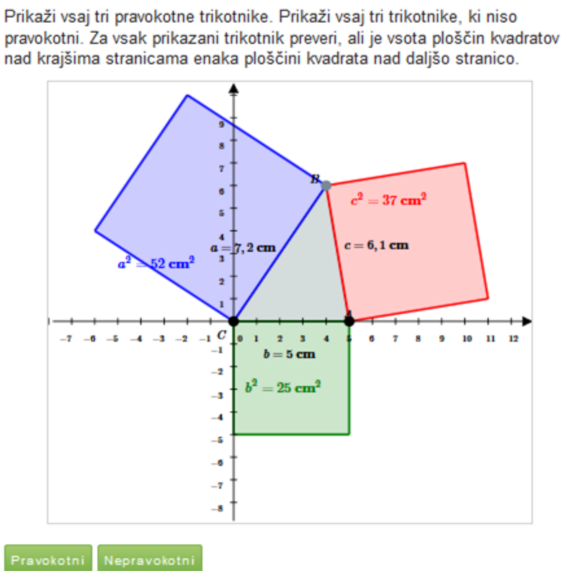


Figure 9: Discovering Pythagorean theorem in an alternative way (Source: http://eucbeniki.sio.si/test/iucbeniki/mat8/842/index3.html)

Similar considerations could be made for the use of an i-textbook in the summary phase (Summary) or consolidation/verification of knowledge (Exercises).

A teacher can also consider the use of more radical concepts on the basis of the relationship between school and home work in building new knowledge. In this context we are referring to the fact, where most of completed work (learning) is done in the phase of building new knowledge at school or at home. For the purpose of this article we identified three options of work and use of an i-textbook: a regular teaching model, partially flipped classroom and a flipped classroom. In the description of each model we will not be evaluating pros and cons of each individual model, because they are based on various factors, which exceed the purpose of this article.

Under the term regular teaching model we understand every form of work in class, in which students acquire a full range of objectives and content associated with a new term or concept within the framework of activities at school, where at home they mostly consolidate their knowledge and understanding. Students also use an i-textbook in a manner provided by a teacher (some of the options were described in the previous section), which should include a sensible method of investigation (problem solving) with the use of interactive elements of an i-textbook, an interview method (and discussion), use of text, encourage students to a sensible use of ICT and to a lesser extent a method of interpretation. Students are active in the phase of building new knowledge at school and consolidate knowledge at home (with generated exercises). In this way we develop declarative, conceptual, procedural and problem knowledge. At home however, they develop only procedural, conceptual and occasionally problem knowledge (a normal model, which may have many derivatives). A teacher uses an i-textbook as a tool for planning and implementation of lessons (on a substantive and didactic level) and he may take on a role of a central "provider" of knowledge or a mentor.

Under the term partially flipped classroom we understand a method of work in which a student acquires objectives and content associated with a new term or concept partially in class and partially by themselves at home. A teacher decides to give homework that instead of developing procedural knowledge (basic consolidation exercises) provides a partial or complete acquisition of a new concept (development of conceptual and/or problem knowledge). Homework is therefore in a function of preparing a student for a new concept (to learn more about the key idea) trough a sensible and an informing motivation (searching examples of use in various sources or setting a problematic situation to experience a cognitive conflict) or through investigative activities in which students discover partial or full determining conditions of a new concept, or they form a separate hypotheses, which relate to a future concept. Learning at home can be asynchronous (every student individually) or synchronous with other students (videoconferencing, Internet telephony, social networks and other communication platforms). A teacher can then build on an already introduced key idea of a new concept and take on a role of a mentor and a director (red thread of an activity) or a producer of key conclusions, while students verify, solidify and build knowledge together with a teacher and with an i-textbook in previously described methods. This provides more time for development of procedural and problem skills.

Flipped classroom is a method of teaching, where students and teachers strive to acquire key objectives and content associated with a new concept within the framework of home learning followed by activities of verification and an upgrade of knowledge under teachers surveillance (Bergmann and Sams, 2012; Flipped Learning Network, 2014). In this case, individual home learning takes place asynchronously or synchronously, but in both cases students process a higher volume of teaching materials (e.g., video lectures, a greater part of an i-textbook unit). Such work requires high internal motivation, ability of self-regulation in learning, sufficient time for work and teachers' support (preliminary preparation of teaching materials for self-paced home learning and option of synchronous communications in case of difficulties in learning). The quality of learning material is especially important. It must be designed with an idea that students will work independently and at the same time enable as much learning opportunities and student-material interactions as possible, which is usually provided through high-quality learning conversation and activities in a classroom. A teacher is no longer a "provider" of knowledge (only implicitly as an author of teaching material), but a mentor, who must monitor any false ideas about new concepts and provide guidance in consolidating and upgrading home gained knowledge. In mathematics, students develop declarative and conceptual knowledge at home and procedural and problem knowledge in school.

I-textbooks are, therefore, a valuable tool for students and teachers in both conventional models of teaching as well as in certain newer forms, such as a flipped classroom, where creative and high quality teaching materials play an important role. A process of knowledge construction is different for each student, because of various perceptual, cognitive and learning styles (Marentič Požarnik, 2003, p. 152-160), while at the same time the nature of cognitive methods in different subject areas is so diverse, that an efficient use of an i-textbook presents a great professional challenge for a teacher, where he must decide which different factors enable an effective construction of knowledge (satisfaction of students), and what are only expectations of an exponentially evolving computer industry. Teachers' main intellectual role is to be a critical observer and not a non-critical consumer of everything that markets and interest groups promote.

Conclusion

The use of i-textbooks in Slovenian school environment has become a reality in the present and most probably also in the future of education with the "E-textbooks for science and mathematics classes in primary and secondary school" project. Fear, mistrust, concerns and doubts are a natural response of a teacher, who is faced with new forms and methods of teaching. Sometimes these novelties are in a virtual or actual conflict with the traditional notions of teaching and learning, and often - quite the opposite - open up new opportunities. We believe that each novelty, that withstands fundamental professional judgement, is worth introducing, testing and being offered to students as an option for a different method of knowledge construction. Which mode of i-textbook use a teacher chooses depends on several subjective and objective factors. The worst kind of a decision would be not to give an opportunity to i-textbooks: today's generations grow up with strong visual stimuli and it is reasonable to use this potential for educational purposes.

For an effective use of an i-textbook, however, it is crucial that a teacher gets acquainted with different options of its use and learns its design concept, while at the same time, thinks about learning opportunities which are offered to students through applets and other activities for an active construction of knowledge.

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WORKSHEET: COMBINATORIAL SITUATIONS

Follow the instructions in this i-textbook. Think about the problem, consult with a schoolmate or a teacher and only then look at the solutions. Use Hints.

Write the title in your workbook.

Page 454 (Combinatorial situations)

c. Complete the first exercise by arranging digits 3, 5 and 7 into three-digit numbers. Read and consider all the text in the section before the title Repetition.

Write down all numbers from exercise 1:

d. Complete the exercises 1, 2 and 3 from Repetition.

Write down the maximum and minimum number from exercise 2:

Write down the resulting numeric expression from exercise 3:

What do we call a systematic arrangement of digits? Circle the correct choice.

A Copying **B** Combining **C** Guessing **D** Repeating

Page 455 (Combinatorial situations)

c. Read the instructions from the first exercise (flowers). You can use the Hint button before you solve this exercise. Fill in the gaps below the spreadsheet.

d. Read instructions on the right. Drag the display point and arrange the flowers.

How can we display combinatorial arrangements? Circle the correct choice.

A In a line **B** In a spreadsheet **C** In a cube **D** With a combinatorial tree

Complete exercise 2, 3 and 4 (page 458, Exercises). Answer the questions.

Exercise 2: What are the odds of Mojca staying in Rovinj for the summer? ____________

Exercise 3: How many choices does Janez have if he can choose between 1 hat and two caps? ____________

Exercise 4: Simona is picking out an outfit. She has a choice of 3 pants, 3 t-shirts and 2 pairs of shoes. How many different outfits can she wear? ________

We can use **a spreadsheet** or **a combinatorial tree** for combinatorial arrangements. The total number of possibilities is calculated **by multiplying all the possibilities at each stage of arrangements**.

Page 456 (Combinatorial situations)

b. Complete the first Example (sitting at a straight table). If you are having trouble solving it, help yourself with the solution.

   Complete exercise 6 (page 459, Exercises). How many different types of cars can Jane buy if she has these options: a pickup truck, an SUV and a caravan, a diesel, petrol or electric engine and two different colours?

   Complete exercise 9 (page 459, Exercises). In how many ways can we arrange John, Luke and Mary in a straight line, if boys always stand next to each other?

a. Solve second Example (plot points on a coordinate grid).

b. Solve fourth Example (Maruša is making dinner) in your notebook.

c. Solve fifth Example (Alma and passwords with digits).

Solve exercises on pages 458, 459, 460.

Exercise 10: Justify why we can not use digit 0 in hundreds' place.

Exercise 12: How many words (that make sense or not) can we form from letters a, t and e if they can not be repeated in the same word.

Exercise 16: 7th grade has Math on second lessons of the curriculum and PTE on third. How many different timetables can we form?

Exercise 19: You toss a coin two times in a row. Write down the odds for T-tails and H-head.

Read the summary.

A students' experience with mathematical interactive e-materials

Alenka Lipovec, Eva Zmazek

This article presents a secondary school student's perspective on working with E-um web portal and i-textbooks. Active learning is set in the framework of social constructivism and illustrated in the following learning scenarios: self-directed learning, flipped classroom model learning, homework, preparation for assessment of knowledge and learning optional content. Every aspect is defined first through research findings and then through representative examples of interactive e-materials. We have focused on the E-um web portal and secondary school i-textbooks Vega 1, Vega 2 and Vega3. What follows is the student's elaborated critical reflection on an introduced learning style. At the end of this article we gain an insight into the user experience of a teacher who effectively uses different spectra of ICT in teaching mathematics. We determined that i-textbooks are an efficient educational resource for students as well as teachers. They motivate and encourage in-depth learning and teaching of basic mathematical concepts.

Key words: user experience, active learning, homework, flipped classroom, optional contents

Introduction

The use of information and communication technology (ICT) for teaching mathematics in Slovenia has been a constant for twenty years. A teacher was predominantly a direct user of this technology in the initial period, but over the last few years, students have also turned into direct ICT users. Students actively apply all available options of use:

a. simplest, such as electronic communications between teachers and students (e.g., e-mail, social networking sites, online classrooms),

b. simple, the use of software tools (e. g., Geogebra, Mathematica, Wolfram Alpha, etc.),

c. use of didactic-substantive quality collections of e-materials (e.g., E-um) and i-textbooks (e.g., Vega1) through various electronic media.

A proper use of social networks, such as Facebook, can have a positive effect on the relationship to mathematics, particularly on students with low self-esteem (Ellison, Steinfeld and Lampe, 2007). The mathematical anxiety, which Zettle and Raines (2000) identified as an uncomfortable condition, which occurs as a response to circumstances that include mathematical exercises, is closely linked to self-esteem and may interfere with future career, which includes mathematics, even with Slovenian students (Lutovac, 2008). The positive effects of simpler forms of ICT (e.g., dynamic geometry programs like Geogebra) are supported by a large corpus of research literature (Hoyles and Noss, 2003). Similarly, the findings on positive effects of the "E-um" portal on knowledge of mathematics and relationship to it (e.g. Lipovec and Kosi Ulbl, 2008) are supported by research. This monograph provides similar conclusion for Slovenian i-textbooks.

The subject of e-materials in Slovenia has been **evolving** through several projects since the introduction of the Internet, but a real **revolution**, from the viewpoint of use in Slovenia, was achieved with the project "E-um", which has followed (later set) guidelines for e-textbooks development since its concept design. In the last period, the growing trend of ICT use in education has seen more and more e-textbooks in digitised form of conventional (printed) textbooks, which exploit the new media only as compensation. This is why we introduced the concept of i-textbook for interactive e-textbooks and started a so-called **ivolution** of textbooks into i-textbooks (e-textbooks, which exploit new media to upgrade interaction with users, enabled by the new technology).

Today, the use of ICT in teaching and learning mathematics has become indispensable. Not only does it help us optimize time and spice up learning and teaching, it allows us to reach a common objective of teachers and students – to achieve an in-depth mathematical understanding and useful knowledge.

In this paper, we will examine the student's experience in using e-materials and i-textbooks for mathematics, which are under the auspices of MoES and the National Education Institute and were made during the period of 2006-2014. From the student's (high school student's) point of view we will direct the attention to the positive and negative aspects of ICT use in key elements of learning mathematics.

Independent learning of students at home

Classic home learning has, just a few years ago, been carried out mostly by the use of printed textbooks. Mathematical textbooks are otherwise substantially correct, but dull in form and especially difficult to understand for weaker students. Different interactivity levels, generated tasks and text placed under the buttons have made many improvements in new i-textbooks, which have been available for only one year. High school students have much more opportunities when studying at home, to take on a more active learner role when dealing with content, because the interactive units encourage them to be more active. On the introduction page of every unit, which encompasses motivation or content contextualisation and repetition of needed prior knowledge, the student already has to engage in active learning. Let us examine, on the example of an introduction to a more demanding mathematical concept, how the definition of active learning is being realized.

Bonwell and Eison (1991) emphasize that in active learning the students must do more than just listen: they have to read (also other source, e.g., SSKJ dictionary as stated under the Figure on the left), write (use mathematical terminology when answering open questions, answers to which are hidden under the two buttons on the right), discuss (when comparing solutions of the exercise on the left with their schoolmates) and cooperate (they are invited to ask their friends on what their height is) in solving problems (abstraction of relations among people into a mathematical concept of relation is certainly a problem, which has no prescribed procedure for creating a solution). Active learning demands development of mathematical competence, meaning of knowledge (e.g., comparison of concepts of operations and relations) as well as skills (in secondary school that means e.g., tabulation) and relationships (through real life examples a positive relationship toward mathematics, which is not something foreign to the reality, is developed among peers).

Active learning demands thinking on higher taxonomy levels: analysis (the third exercise on the right demands degradation to sub problems, because each record has to be analysed independently), synthesis (connect common properties of people on the photographs in the photo album on the left, this is only the first step to abstraction of relations as a mathematical concept) and evaluation (photographs are carefully chosen to provoke critical thinking). Active learning encourages two aspects among students: they are doing something and also thinking about what they are doing.

As the unit continues, after the initial motivation and repetition of prior knowledge, the roles of interpreter and learner are also actively exchanging on the so called core pages. These sites also enable an effective differentiation of content and learning pathways, because they are an appropriate design concept. The importance of detecting key ideas is of crucial importance in mathematics (Wheatley, 1991). Because students are at the beginning of their path to discover mathematics, the technology can help them by hiding more difficult derivations, less important comments and interesting facts under the buttons and additionally highlight key content emphasis.

As an already established and effective learning pathway in a classroom a content summary is made at the end of every unit of the new i-textbook, which allows the students (interactively) to repeat what they have learned in the unit. By doing so, they reconstruct their cognitive schemes through the processes of assimilation and accommodation (Labinowitcz, 1989) and adds new concepts to their "world" of mathematical concepts, which are connected to the already known concepts. Because understanding is defined as a measure for quality and quantity of connections of a newly formed idea with already existing ides (Skemp, 1976), students actively deepen their understanding.

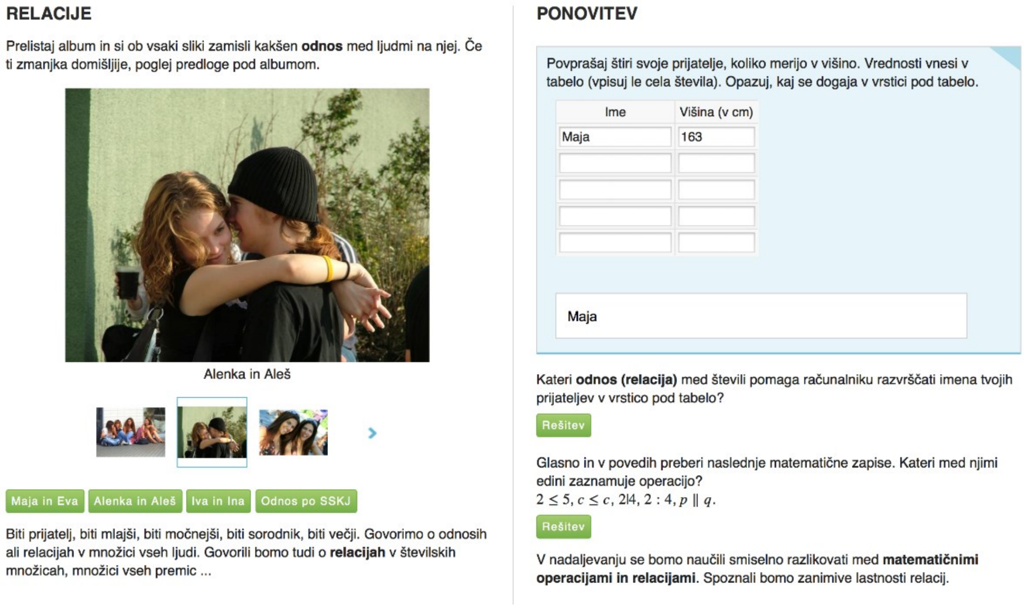


Figure 1: Active independent learning on the introductory page of the learning unit (Source: http://eucbeniki.sio.si/test/iucbeniki/vega1/3/index.html)

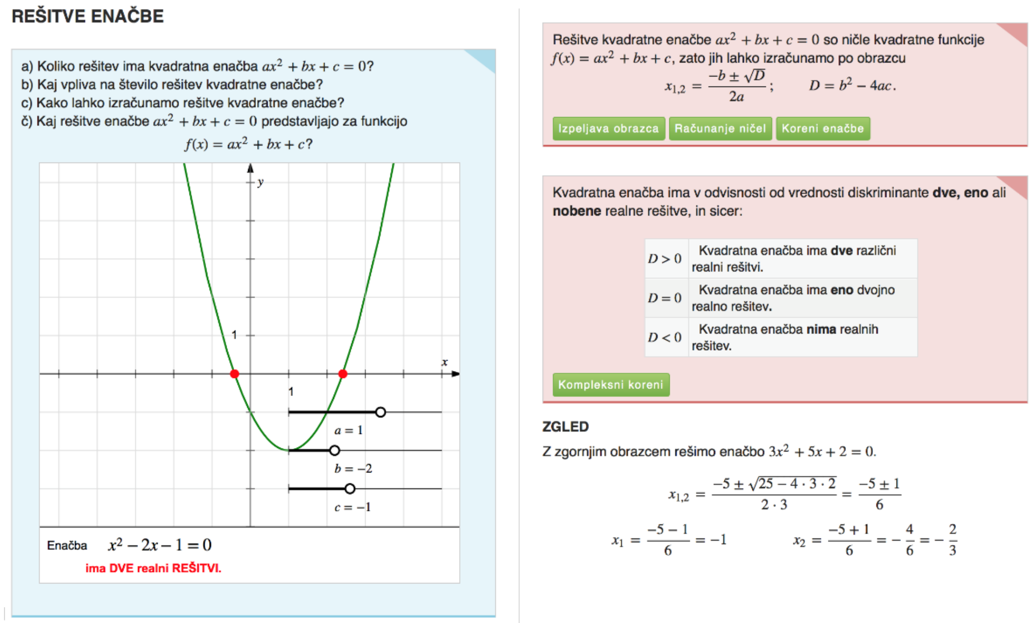
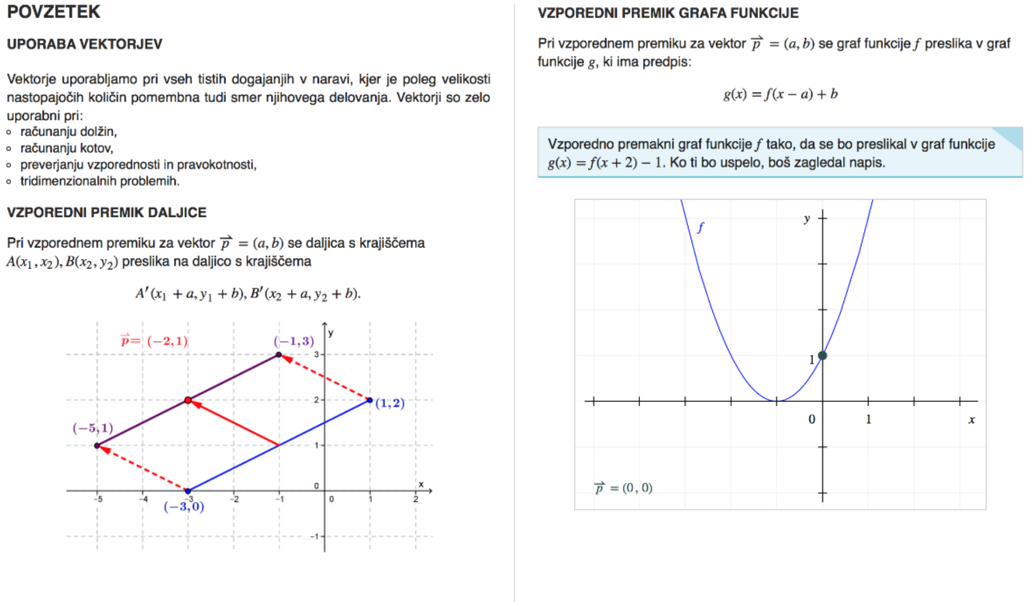


Figure 2: Active learning on core pages with the emphasis on key concepts (Source: http://eucbeniki.sio.si/test/iucbeniki/vega2/282/index2.html)



POVZETEK

UPORABA VEKTORJEV

Vektorje uporabljamo pri vseh tistih dogajanjih v naravi, kjer je poleg velikosti nastopajočih količin pomembna tudi smer njihovega delovanja. Vektorji so zelo uporabni pri:
- računanju dolžin,
- računanju kotov,
- preverjanju vzporednosti in pravokotnosti,
- tridimenzionalnih problemih.

VZPOREDNI PREMIK DALJICE

Pri vzporednem premiku za vektor $\vec{p} = (a, b)$ se daljica s krajiščema $A(x_1, x_2), B(x_2, y_2)$ preslika na daljico s krajiščema

$$A'(x_1 + a, y_1 + b), B'(x_2 + a, y_2 + b).$$

VZPOREDNI PREMIK GRAFA FUNKCIJE

Pri vzporednem premiku za vektor $\vec{p} = (a, b)$ se graf funkcije f preslika v graf funkcije g, ki ima predpis:

$$g(x) = f(x - a) + b$$

Vzporedno premakni graf funkcije f tako, da se bo preslikal v graf funkcije $g(x) = f(x + 2) - 1$. Ko ti bo uspelo, boš zagledal napis.

Figure 3: Summary as help in organizing the cognitive scheme (Source: http://eucbeniki.sio.si/test/iucbeniki/vega2/1063/index5.html)

Learning in the flipped classroom method

In Slovenia, a teaching method became popular, where students prepare for new content at home, most commonly by going through material prepared by a teacher. The method, called "flipped classroom", is based on the presumption that the student would get the needed knowledge of the lower taxonomy levels by doing some work at home, and then together with the teacher by working in class, which would make it easier and quicker to tackle the exercises and challenges leading to problem-knowledge (Bergmann and Sams, 2012). One of the problems of this method is to persuade teachers to dedicate a lot of their free time to making material for students, which will allow students to go through a part of the content independently; that is why i-textbooks caused a lot of interest among the experts, who work on establishing this method.

The units of new i-textbooks with a few additional (more specific) teachers' instructions are actually exactly what teachers should make. The first experiences of teachers in Slovenia and abroad were great. The students in Slovenia were also interested in this new method. Let us mention one of the hidden traps of the FC method. It is very time-consuming, and it also demands maturity and responsibility of students, who in our educational environment still lack the competence for independent research. It is, however, one of the key methods that helps deepen the knowledge of lower taxonomy levels to problem-knowledge.

Homework

One of the crucial elements on the path to good knowledge in mathematics has always been homework. Regular (but not overwhelming) mathematical homework has a positive effect on mathematical achievements, where the teacher's monitoring of executed homework does not basically impact greater achievement (Troutwein, Köller, Schmitz and Baumert, 2002). In the era of ICT, the communication regarding homework between the teacher and the student does not take place only in the classroom, but also via on-line communication channels (e-mail, Facebook, on-line classroom etc.). Such communication eases problem solving, which might arise for students when doing homework, but it is the simplest example of ICT use in education.

When students prepare for written assessment of knowledge, it is very important to also repeat the contents, which served as prior knowledge in new contents. Since these contents often come from lower classes and students, due to textbook fund loans, cannot access those printed textbooks, this makes the use of electronic materials or i-textbooks even more frequent. These are, namely, freely accessible for all years/grades of secondary school (even for every grade of the primary school) in the same place.

The access to contents from every year (also grades) is proven to be especially useful when studying (preparing) for matura. When preparing for matura most students will only use summaries and some students, who will need a more in-depth repetition of knowledge, due to their difficulties in mathematics, will be able to completely work through problematic content with units.

New i-textbooks open new possibilities regarding homework. With generated exercises, the user of the unit can always recall new data with the same exercise, which is also frequently fitted with directly changing graphic presentation. Level choice of homework and immediate feedback are offered simultaneously.

Generated exercises are interesting from both teacher's and student's point of view. They enable the teacher to verify whether students are doing their homework independently, because cheating is not possible. The student can also practice a difficult procedure over and over again with new data. We must emphasize/mention/warn that generated exercises are especially appropriate for acquiring procedural knowledge, but much less for the challenges leading to problem -knowledge.

New i-textbooks also offer, beside generated exercises, an extensive collection of ordinary practice exercises, which are placed at the end of every unit and could offer a quality exercise book when shelled out of the units. The advantages of an exercise book as a source of homework for students learning independently are numerous. The exercises are structured from easy to difficult, which is clearly marked for the user (green – least difficult, blue – difficult and red – most difficult). A responsible student will, therefore, start with least difficult exercises. When they become (perhaps) too easy, they will focus on more difficult exercises and may even complete some additional challenges.

The buttons, which are placed directly below an exercise, often contain a hint. These buttons also contain a solution of an exercise, which saves a user (teacher and student) a considerable amount of time, if a user wants to check the accuracy of the result. In printed workbooks we have to look at the end of a section or even on the last pages for a solution. Theses buttons sometimes contain a path to the solution, which can help students in solving exercises. However, it should be noted, that some students are unable to resist the temptation of looking before they even bother to solve an exercise.

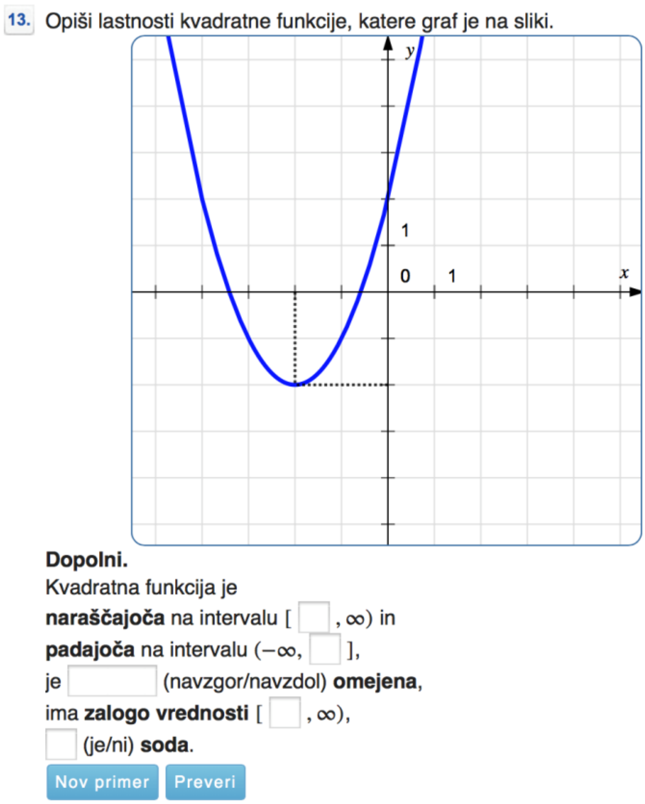


Figure 4: A generated exercise with changing data used as homework (Source: http://eucbeniki.sio.si/test/iucbeniki/vega2/278/index11.html)

Preparations for the assessment of knowledge

Importance of regular verification and evaluation of mathematical skills, which encourages students to take active responsibility for their own knowledge, is explicitly stated in the national curricula (Žakelj et al., 2011). Written examination in mathematics is often so stressful that it is difficult to distinguish between mathematical and general anxiety (Gierl and Bisanz, 1995). This is why students (especially in high school) prepare for examination with the help of many available resources.

In preparation for written and oral assessment of knowledge, students, in addition to printed workbooks and textbooks, often look for help in form of additional interpretations, summaries, and collections of exercises on the Internet. The "E-um portal" has been an unique resource in the Slovenian educational environment. "All in one place" was an unwritten slogan for teachers and students, which is why the "E-um" portal was massively used.

When students prepare for written assessment of knowledge, it is very important to repeat the contents, which served as prior knowledge in new contents. Since these contents often come from materials of lower grades and other students, these are often inaccessible, because they are often loaned from the textbooks fund, which makes students use electronic materials or i-textbooks even more frequently. These are freely accessible for all years/grades of secondary school (even for every grade of primary school) in the same place.

The accessibility of contents has proven especially useful when studying (preparing) for matura. When preparing for matura, most students will only use summaries, while others, who need a more in-depth repetition of knowledge, due to their difficulties in mathematics, will be able to completely work through the content.

The "E-um" portal enabled, for the first time in history of e-materials, access to generated exercises and generated exams, which includes exercises from specific chapters that were randomly generated with the application on the portal.

Figure 5: The Exam generator as a source for preparing for assessment of knowledge (Source: http://www.e-um.si)

New i-textbooks provide many more generated and other exercises which offer even more interactivity then the "E-um" portal. However, an option to generate exams from a specific set of exercises is not yet available.

Optional content

Curriculum for mathematics in gymnasiums (Žakelj et al., 2008) is divided into sets, with specific definitions of what falls within the scope of basic, special and optional knowledge. Although most lessons cover basic and special knowledge and rarely optional knowledge, the use of new i-textbooks offers new options.

I-textbook covers all knowledge: basic, special and optional. There are not many traditional textbooks that would cover at least some optional content, which makes i-textbooks a welcome tool for more curious students. Special and optional knowledge are specifically marked for each unit in an i-textbook.

Optional knowledge may function as a support for differentiation of school and home work, as well as for various school groups/clubs or as basis for seminar papers and research tasks.

Use of an i-textbook in class

Math is one of the subject areas where depth of understanding relationships between new concepts is of greatest importance for a student (Skemp, 1976). A teacher can offer help in very simple ways or encourage students to help themselves. Let us look at an example of an exercise, where a teacher, who is well versed in the use of Geogebra, helps a student to visualise and facilitate understanding of the concept.

Example: Determine the value of the parameter a, so that the line will present a tangent line of a parabola.

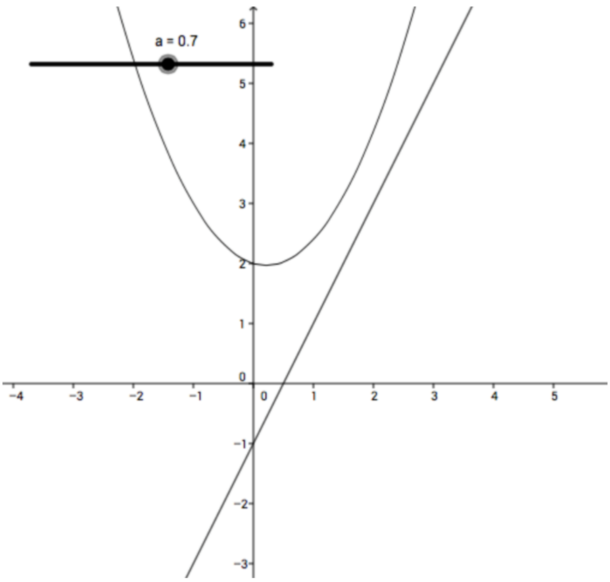


Figure 6: An applet completed in class.

It makes sense that a teacher solves this exercise with Geogebra directly in class and not with a prepared applet. A student is then unknowingly learning to use this tool and will be able to complete similar challenges alone at home.

When development of an applet you would like to use in class is time consuming and technically difficult, it is much better to use a collection of already prepared applets. Some examples of such applets, which helped students to better understand combinatorics, are presented below:

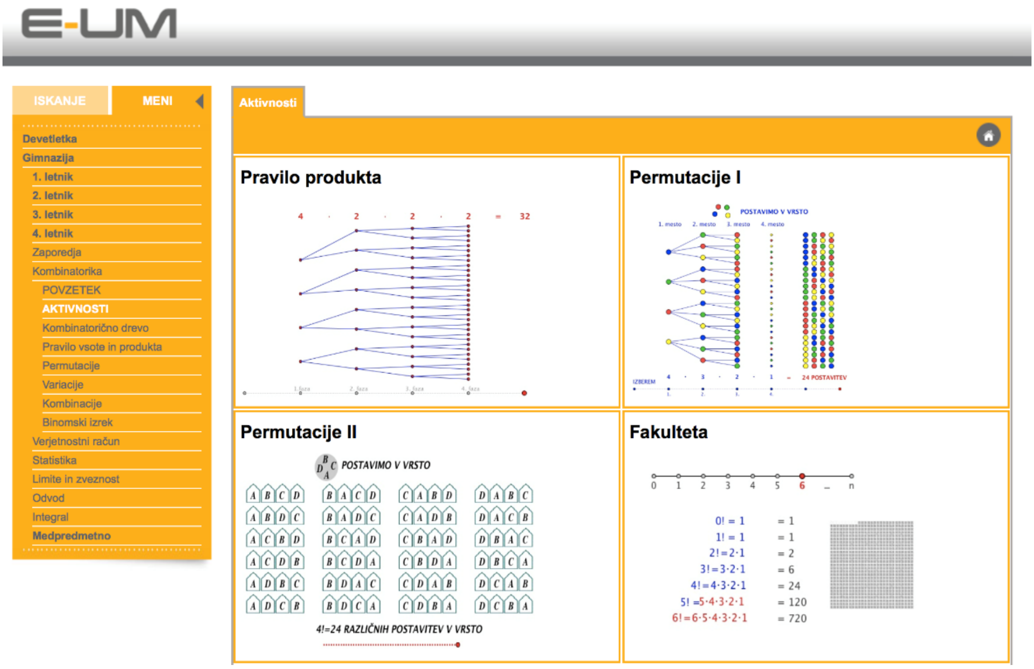


Figure 7: Various pre-prepared applets (Source: http://www.e-um.si)

A teacher can use an applet with frontal instruction, but it would be even better to encourage students to investigate the applet by themselves, especially in classes equipped with computers or tablets.

For independent research in class, the most appropriate applets are those with high levels of interactivity, which are defined and described by Repolusk, Zmazek, Hvala and Ivanuš Grmek (2010). With these applets student may learn independently by repeating activities and diverse data sets and discover new connections between already known concepts. New i-textbooks contain significantly more of these applets than existing collections of e-materials. These applets are an educational challenge for a teacher, because they must motivate their students to work with them. However, they can lose their value, if a teacher uses them only as enrichment to their own interpretations.

Lessons, where a teacher directs students to reading already developed e-materials and individual units of an i-textbook, are interesting for students, however, this method has a few traps. Students' motivation can deteriorate rapidly and the use of computers or tablets offers many opportunities for other forms of entertainment (non-educational). This risk is reduced if a teacher clearly defines work instructions and expectations at completion of work. We must also be aware of great advantages, particularly in developing effective differentiation in classroom, as students may adjust the speed of learning and a teacher may offer various paths to adoption of new content. Differentiation, particularly in mathematics, is a problem due to different levels of students' prior knowledge. Teachers have been working to solve this problem for a long time, but it seems that it is extremely difficult to solve (Žakelj, 2012). Technology can most likely offer great help in solving this problem.

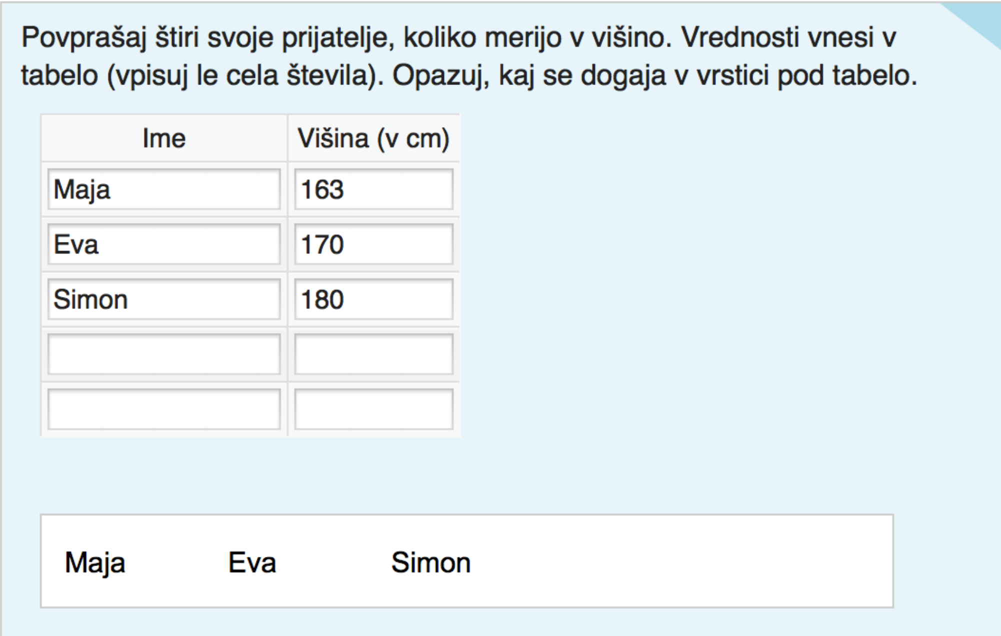


Figure 8: Pre-prepared applets with high level of interactivity (Source: http://eucbeniki.sio.si/test/iucbeniki/vega2/278/index1.html)

Conclusion

The use of ICT in education has been getting closer and closer to its essence in the last twenty years. We, the teachers and students, have learned how to use programmes and tools and in this phase we have, perhaps, neglected the contents, but now the user experience has become so reinforced that the use of ICT became so familiar, that we can again focus on the contents. Didactic use value of ICT in learning and teaching mathematics is constantly increasing.

Advantages of i-textbooks in learning at home are numerous. With a more active learner’s role and a new textbook design we developed a virtual instructor who helps weaker and also more curious students. Textbooks also help students with special needs, especially because of the content visualisation, and students with a specific status, who are often absent form school. Because i-textbooks are freely available online they can accompany us everywhere with no additional luggage.

Just as we could not imagine where the use of ICT in education will lead us, today, we cannot imagine what a classroom will look like in ten years. Perhaps it will be no longer needed in its current physical form. Perhaps a future classroom will exist as a motivational place somewhere on the internet and i-textbooks, along with new forms of communication between a computer and users and between groups of users, will replace currently embedded forms of work in classrooms. The progress of i-textbook developers in Slovenia is very fast, so there is no doubt that they will be able to add new forms of use to i-textbooks, where all users' activities will be easily recorded so that teachers will be able to access and direct their work. Perhaps the future i-textbooks will enable different interpretive learning paths and programmed learning, in which a computer will be able to detect, through activities of a user, how much knowledge they have and guide a user to the most optional educational path.

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I-textbooks for chemistry – views of the editors

Margareta Vrtačnik, Boris Zmazek

E-learning in the field of chemistry was brought into the Slovenian educational space with the project "E-chemistry". The present project "E-textbooks" upgraded and supplemented its content, so that the present e-chemistry textbooks cover the entire teaching of chemistry vertically, from the 8th grade of primary school to the 3rd year of high school. Multimedia elements are particularly important in chemistry education, since they enable the interlinking of the macroscopic, submicroscopic and symbolic level of concepts' and processes' perception. Therefore, we devoted special attention to their design and attempted to follow theoretical developments in this area. We are aware that in the future we will need to incorporate into multimedia elements more of the findings on the factors that influence their efficiency; moreover, knowledge integrated approaches will need to be developed. The extent to which chemistry e-textbooks reach their aims will depend on the teaching strategies for their implementation in school practice. Research into the use and educational value of e-teaching materials will provide answers as to the actual value of e-units and will highlight their advantages and deficiencies.

Key words: E-textbooks, chemistry, multimedia elements, e-unit design

Introduction

The overview of scientific literature in the field of e-education on WEB of Science shows a distinct increase in the number of publications on e-education, especially in 2005 -- 2011 (Vrtačnik, Dolničar, Schlamberger in Svoljšak, 2012). The research by Caballe and Xhafa (2010) confirm that there is an especially increased interest for cooperative e-learning in the last decade, with growing needs for more demanding pedagogical approaches and technical solutions, which have to enable the adaptation of e-education systems to the needs of specific groups' users. We have to be aware of the fact that the introduction of information and communications technology (ICT) in the education process requires not only a change in didactic approaches, but also the studying of various other factors which ensure a quality integration of ICT in the education process. The lack of compliance and knowledge of these factors is commonly reflected in improper use of ICT and even in lower quality of education (Yang, 2012). An important factor of successful integration of ICT in education is teacher who play a significant role in transmitting changes enabled by ICT in teaching and learning. Without appropriately educated teachers we cannot expect positive effects of ICT introduction on education, that is why today in almost every programme for teachers' education, also our own, there is a strong emphasis on the use of ICT in specific expertise areas, where technological aspects of ICT and especially didactic approaches of ICT integration are at the forefront (Donnelly, McGarr in O'Reilly 2011; Rezaei, Nazarpour, Emami, 2011; Vrtačnik and Ferk Savec, 2009; Barton, 2005).

Forms and meaning of multimedia elements for chemical education

To design e-materials for chemical education, the multimedia elements are especially important, because they connect three levels of perception and with that also the understanding of chemical concepts on a macroscopical level (experiment recordings), submicroscopical level (process animation and simulation at the level of particles and manipulation with virtual 3D models of molecules and crystals) and symbolic level (chemical equations and reaction schemes). For visualisation of the submicroscopic world of chemistry we use molecular modelling to display structure and surface properties of crystals and molecules with animations, simulations and increasingly more with integrated approaches (knowledge integration).

Dynamic visualization is based on a wide set of interactivity properties: adjusting the speed of visualisation to perception (animation), indirect interference in the process of visualisation (interactive animation), possibility of changing the process parameters, which affect the results of visualisation. The latter forms of visualisation are based on processes simulations (Tversky, Morrison and Betrancourt, 2002; Betrancourt and Tversky 2001) and can gain additional didactic value if based on the principle of knowledge integration. In the process of knowledge integration the users connect valid scientific ideas with their own ideas and gradually developed coordinated, integrated understanding of scientific concepts and processes (Linn and Eylon, 2012). The frame of knowledge integration includes four processes, which encourage integrated understanding: (a) provoking ideas, (b) expanding the set of ideas, (c) differentiation among the ideas and (d) sorting of ideas. Integrated interactive dynamic visualisations on the basis of processes simulations enable the learning population to plan and implement experiments, control variables, formulate hypotheses and verify research hypothesis in virtual laboratory (Hsin-Yi Chang, 2013; Windschitl, Thompson and Braaten, 2008). They, therefore, become aids to simulations of real, but simplified research work.

Numerous authors (Chang, 2013; Zhangin and Linn, 2013; Ryoo and Linn, 2012) report on the impact of integrated dynamic simulations depending on the strategies of inclusion in the learning process, on the quality of knowledge or understanding of scientific concepts in the field of chemistry and related sciences. The research results have shown a significant contribution of dynamic simulation, teachers' logistic and conceptual managing of the learning process on the understanding of the examined processes from the field of science. The students who were included in the group of dynamic visualisation were substantially more successful in articulating the observed process and they have also shown a more integrated understanding of the process of connecting their own ideas with other processes.

Due to financial, technical and time limitations in preparing e-textbook materials to illustrate chemical concepts and processes on a particle level we have used primarily interactive virtual models and animations, therefore we have elaborately studied their impact on the learning outcomes in scientific literature.

Even though animations are supposed to assist learning, especially with demanding scientific concepts, the research does not always corroborate their positive cognitive impact. It seems that animations can be effective in conveying dynamic information, but presentation has to be clear and simple. Research on the use of animation in the learning process shows that implementing or integrating animations in a learning environment influences the cognitive load and consequently executive control of the working memory. This can be significantly decreased, if animations increase the cognitive load, or increased, if animations have the opposite effect. That is why the majority of research in the last few years is directed to studying factors, which influence the load of the working memory and with that also the efficacy of animation as a learning tool (Hatsidimitris and Kalyuga, 2013; Spanjers, van Gog, Wouters and van Merrienboer, 2012; Chien and Chang, 2012; Lai and Newby, 2012; Lin, 2011; Scheiter and Gerjets, 2010; Rebetez, Betrancourt, Sangin in Dillenbourg, 2010; Wu, Chang, Chen, Yeh, Liu, 2010). As factors which increase the learning efficiency of animation, researchers, Wu et al (2013), Falvo and Suits (2009), stress the development of spatial perception and use of presentation strategy, first of the images of the process and then of the animation. The key findings confirm that well developed spatial perception contributes to understanding of an animation. Perception is also influenced by gender; statistically women had better results than men in a test population. Hatsidimitris and Kalyuga (2013), Hoeffler and Schwartz (2011) add that an option to control the animated process and to adapt it to a person's perception capability is crucial for understanding animation.

The use of virtual 3D-molecular models for understanding molecules properties was studied by a variety of authors: Ferk Savec, Vrtačnik, Gilbert and Peklaj, 2006; Ferk Savec, Vrtačnik and Gilbert, 2005; Ferk Savec, Vrtačnik, Blejec, and Gril, 2003; Canning and Cox, 2001, Dori snd Barak, 2001; Barnea, 1997; Hyde, Shaw, Jackson and Woods, 1995. They state that the use of virtual models and modelling contributes to a better understanding of, especially, organic chemistry and that the influence on understanding concepts depends on the age of test subjects. However, both traditional and virtual molecular models have their advantages and disadvantages, Dori and Barak (2001). The authors recommend the use of both. Using a combination of models contributes to a deeper understanding of chemical concepts and eases the conversion of three-dimensional shape of molecules into two-dimensional and a symbolic presentation. Study by Ferk et al (2005) has additionally shown that successfulness of the molecular models' use depends on the state of development of spatial perception. Test subjects with well developed spatial perception have successfully used traditional, physical and virtual molecular models, regardless of their age. They also had no difficulties in converting presentations from 3D to 2D. However, most of the test subjects preferred a physical model due to it being more explicit and tangible. The researches recommend that students start with traditional physical models when learning new concepts and then gradually substitute those with pseudo 3D-virtual models. Simultaneous use of both is not recommended, because the divided attention lowers the effectiveness of model use in learning and teaching chemistry.

Our experience with e-learning in chemistry

Since 2008, the portal E-kemija (http://www.kii3.ntf.uni-lj.si/e-kemija/) is available to Slovenian students and includes 125 e-units for primary and secondary school. The portal was created with financial support from the Ministry of Education and Sport of the Republic of Slovenia (MoES) and the European Social Fund (ESF).

All units are based on the new chemistry curricula and designed to strengthen independent learning and/or preparation of students for new knowledge. The statistic of portal use, which we had to monitor for a few years after the project ended, has shown a remarkably high degree of portal use, especially towards the end of school year when final grading and preparations for tests and baccalaureate were taking place. Nevertheless the actual value of the portal and ways of didactic inclusion of e-units in teaching chemistry could not be completely researched, due to lack of funding for this sort of research. Only partial research was conducted, mostly as a part of diploma works of the students of Faculty of Education in Ljubljana. The most recent research was conducted in 2013, when graduate (now a professor of chemistry and biology) Rahela Žagar studied the impact of independent work with the e-unit "Estri" (Esters) on the knowledge of 9th grade students of primary school. Her findings were not in accordance with expectations. The research shows that our primary school students do not have a serious approach toward independent work, because the majority did not even read the e-unit's text and only carelessly watched the videos of experiments, without trying to grasp the experiment's essence. Some students purposely closed the portal and started browsing for more entertaining content or started asking inappropriate, even rude questions, which were an interruption for those students, who wanted to learn something new in the process of working with the e-unit. The key problem was identified as lack of prior knowledge or inappropriate attitude toward their own knowledge. Most of the questions in the pre-test and after-test had wrong answers or no answers at all. We are aware that the inappropriate attitude toward knowledge is partly a consequence of the legislation favouring permissive education, which is limiting teachers in realizing their educational mission; this was also realized by Hamilton, 2009, in her criticism of the English educational system with a very meaningful title "Putting words in their mouths". Teachers have a direct contact with their students and can do a lot to contribute to the change in students' attitude toward work and knowledge through appropriate didactic approaches, authoritarian style of teaching and consistent insistence on the quality of knowledge (Walker, 2008; Gomez, 2005). Our experience, even though modest, is also important for e-textbooks. We have to be aware, that the only way for e-textbooks to reach their purpose and justify the invested financial means will be, if a teacher will know how to appropriately present and integrate them in their own work, so that students experience them as an important addition to a teacher's explanation in chemistry classes.

How were chemistry e-textbooks developed?

In designing e-units for the project "E-handbooks for chemistry" the chemists have used our vast didactic knowledge and valuable experience in working with programmes for preparation of e-units and with programmes for design of multimedia elements, which we acquired as partners or even as lead partners of domestic and foreign educational projects in the field of e-education. A few of us, authors, are partners of a research group SAR "Research on learning and teaching in contemporary society" (head of the programme: Full Prof. Glažar, PhD, Faculty of Education) since 2008. In 2008-2009 we have been a part of the MoES and ESS project ''Development of Science Competences'', in 2008 the project "E-chemistry" (MoES and ESS), in 2004-2007 in MVZT and SAR applied project "Development of ICT tools to enhance the understanding of natural science, chemical concepts and critical thinking skills", and in 2002-2004 in MVZT applied project "ICT for teaching and learning chemistry". We have also been a partner in two resonating international Leonardo da Vinci projects: in 2005–2007 Sloop "Sharing Learning Object in Open Perspective" project, in 2009–2011 Sloop2desc "Sharing Learning Objects in an Open Perspective to Develop European Skills and Competences". In both projects the Institute for Educational Technology Palermo, Italy was the head of the project. Beside practical experience, we tried to integrate as much theoretical knowledge on factors affecting educational value of these elements as possible in the preparation of, especially multimedia, elements.

Chemistry E-textbooks, from primary school to general upper secondary school (gymnasium)

The basis for "Chemistry e-textbooks" were e-units developed in the "E-chemistry" project, which already followed the new chemistry curricula in primary and secondary school in their preparation. In the National Education Institute's project "E-textbooks" we have seen an opportunity to enhance chemical contents and preparation of e-textbooks for the whole vertical of science education and chemistry from the 6th grade of primary to the 3rd grade of secondary school. Because of the newly defined project guidelines, the adaptation of already existing units was needed, not only visually, but also substantially and didactically. A special emphasis was put on interactive elements, which had to be added, updated or modified in every unit. We were especially careful not to overload e-units with multimedia elements, because that would have a negative effect on memory and learning. The missing contents had to be fully redesigned. Both editors have specified guidelines for designing chemistry e-textbook on the basis of general project's guidelines and theoretical knowledge on e-learning for all five textbooks. We have invited all authors from previous projects to cooperate in writing the units. Most authors have gladly cooperated in the project, despite a short deadline. Some authors have completely or partially denied cooperation during e-units preparation, because they were unable to follow the deadlines. This issue was solved by finding new authors, and some units were distributed among the other authors. Finally all 170 e-units for all 5 e-textbooks were ready on time, 31 for the 8th grade, 34 for 9th grade of primary school, 34 for 1st grade of secondary school, 29 for 2nd grade of secondary school and 39 for the 3rd grade of secondary school.

In the framework of the "E-chemistry" project we also prepared chemistry units for the science class in 6th and 7th grade of primary school. These units were also prepared for the e-textbook, which is still in development, because the authors of content on physics and biology joined the project at a later time. The titles of all e-textbooks units for chemistry are presented in Table 1, 2 and 3 according to grade.

6th grade	7th grade
Substances are made of particles	Pure substances and mixtures
Substances as material	Elements and compounds
Dangerous substances	Water
Rocks and minerals	Solutions
Rock cycle	Separation of compounds
Soil	Chromatography
	Physical and chemical changes
	Chemical reaction

Table 1: Titles of e-units of the chemical part of the e-textbook Science

The authors have submitted their prepared e-units on the project portal, revised by two editors and then returned to authors if the unit was not in accordance with the set guidelines or substantively and didactically appropriate for student population. Units deemed appropriate by the editors were sent to a reviewer practitioner and a consultant at the Institute for Education. Reviewer practitioner and consultant are in charge of assessing the accordance of content with the curriculum and the adequacy of content presentation. If the unit was in accordance with the project guidelines and curriculum, it was finished and sent to technical editing. If not, it was returned to the author for supplementation or revision.

8th grade	9th grade
Chemistry - science of substances	Organic and inorganic substances
Substances	Organic substances are compounds of carbon
Atom and molecules	Presentations of organic molecules
Symbols and formulas	Introducing hydrocarbons
Atom structure	Same, but different – isomerism
The formation of ions	Sources and properties of hydrocarbons
Periodic table	Reactivity of hydrocarbons
Ionic bond	From small to big – polymers
Covalent bond	The impact of hydrocarbons on the environment
Polar and non-polar molecules	Hydrocarbons – assessment of knowledge

Properties of compounds	Alcohols - water's relatives
Chemical change	From alcohols to carboxylic acids
Reactants and products	Esters are our good friends
Law of conservation of mass	Polyesters
Balancing chemical equations	Presenting fats
Exothermic and endothermic reactions	Properties of fat and soap
Chemical reaction - exercises	Consolidating knowledge
Sources of elements and compounds	Carbohydrates - mono- and disaccharides
Relative atomic mass	Carbohydrates - the polysaccharides
The main groups of the periodic table	Nitrogen containing compounds
Metals	Amino Acids
Nonmetals	Proteins
Selected elements	Properties and functions of proteins
Elements - exercises	Synthetic polyamides
Defining acids and bases	Nylon synthesis in the virtual laboratory
Acids and bases in the environment	Consolidating knowledge
Indicators	Basic chemical unit - mole
Neutralization and pH	Molecular weight
Solutions	Consolidating knowledge
Acids, bases and salts - the impact on the environment	The impact of light on colour perception
Acids and bases - exercises	Object properties and colour detection
	The impact of eyes and brain on colour detection
	Smell perception, the properties of fragrant compounds
	Chemical composition and extraction of essential oils

Table 2: Titles of e-textbook e-units for chemistry in 8th and 9th grade

Completed units were then revised by an editor and finally by an expert reviewer. The reviewers' comments were then inspected by editors and were mostly taken into account. Before approving a textbook all units were inspected by a technical editor. At the time of formation of this text four e-textbooks for chemistry have already been approved and the fifth has been sent for approval. All textbooks are currently available for the participants of the pilot project "The deployment and use of e-content and e-services" and the project "Testing and use of e-content and e-services".

1st year	2nd year	3rd year
Chemistry is an experimental science	The rate of chemical reactions	Carbon, the key element in organic compounds
Basic laboratory utensils and tools	The impacts on the chemical reactions rate	The structure of organic molecules
Safe work in the school laboratory	Chemical equilibrium	Division of organic compounds
Basics of toxicology	Calculating equilibrium concentrations	The hybridisation of C-atom
Atom structure	The impact of the concentration on the equilibrium	Nomenclature of organic compounds
Isotopes	The impact of temperature and pressure	Hydrocarbons - the influence of isomerism on the physical properties
Electron configuration	Equilibrium reactions in industry	Reactivity of hydrocarbons
The structure of an atom and periodic table	Nomenclature of acids, bases and salts	Use of hydrocarbons and the impact on the environment
Formation and size of ions	Strength of acids and bases	Structure, properties and acquisition of halogenoalkanes
IUPAC nomenclature of binary compounds	Acid dissociation constant and Base dissociation constant	Reactivity of halogenoalkanes
The ionic and covalent bond	pH	Halogenated hydrocarbons and the environment
Electronegativity	Neutralisation	Alcohols
Presentations of organic molecules	Titration	The structure, properties and testing of aldehydes
The shape of molecules	Salt hydrolysis	Occurrence and reactivity of aldehydes
Polarity of molecules	Ionic reactions in solutions	Ketones - the relatives of aldehydes
Metallic bond	Oxidation and reduction	Keto-enol tautomerism

Molecular bonds	balancing equations of redox reactions	Structure and properties of the carboxylic acid
Hydrogen bond	Galvanic cells	Syntheses of carboxylic acids
Structure and properties of solids	Redox series	Reactivity of carboxylic acids
Amount of substance	Electrolysis	Carboxylic acid derivatives
Chemical calculation	The amount of discards substance	Carbohydrates - oligosaccharides and polysaccharides
The volume of gases	The periodic table	Lipids - structure, divisions and properties
The general gas equation	Preparation of coordination compounds	Saponifiable and non saponifiable lipids
The equation of chemical reactions	Coordination compounds	Lipids - their importance for the organisms
Quantitative importance of chemical reactions	Some of the important metals	Surfactants
Energy changes	Aluminium	Consolidating knowledge on oxygen organic compounds
Calculation of standard reaction enthalpies	Use of NH3, NaOH in CaCO3	Amines are organic bases
Alkali metals	Technologically important acid	Amines are nucleophiles
Halogens	Modern technologies	Amino acids - molecules of life
Solutions		Primary and secondary structure of proteins
Mass fraction		Importance of proteins for life
Concentration of solutions		How to eat healthy
Converting the solution composition		Polymers are all around us

Dilution, concentration and mixing of the solutions		Syntheses of polymers
The importance of solutions		Chemical composition and colour of compounds
		The importance of natural dyes in physiological processes
		Groups of natural dyes

Table 3: Titles of e-textbook units for 1st,, 2nd and 3rd year of Gymnasium

Structure of an e-learning unit

The content of chemistry e-textbooks is structured with a table of contents according to content sets and covers complete curricula for primary and secondary school. Each content set encompasses e-learning units, which meaningfully cover the content for minimum one and maximum three school periods. We have covered 353 periods of chemistry with all e-textbooks. Teacher can use individual parts of e-learning units and students can use e-textbook for independent learning, because all units are written in a clear language, divided in smaller sub-units for gradual knowledge acquisition, repetition, consolidation and assessment. The authors have tried to include an appropriate number of interactive elements, which encourage students to curiosity, activities and creativity. Each e-learning unit has the following structure:

– Title: It is as short as possible and may be followed by a subtitle.

– Introduction: includes presentation of a problem or content of an e-learning unit in the form of motivation. Motivation is followed by one or more exercises, with which we examine the needed prior knowledge for understanding new contents of the e-learning unit.

– Body: is intended for acquisition of new knowledge. The users acquire new concepts, skills and competences and carry out activities. Some units also contain certain concepts which go beyond the curriculum. These contents are specially marked in the units and enable more demanding students upgrading of individual contents.

  With sample exercises they regularly examine whether they understood the learning content and if they achieved set goals. There are enough illustrations and appropriate examples in the body, pertaining to the e-unit's content.

- **Conclusion**: contains a short summary and a set of exercises for consolidation and repetition. The exercises are divided into three difficulty levels: green relating to minimum standards of knowledge, blue check achieving basic skills, red provide for more demanding knowledge in curricula.
- **Sources**: list of sources used in writing the units, mainly for visual material.

In the new chemistry curricula there is a strong emphasis on the use of visualisation tools and the authors realized that as much as they could within the means, provided by the program for e-unit preparation eXeCute. Learning units therefore include rich visual material, videos of experiments showing chemical changes on the macroscopic level, animations to interpret processes at a particle level, interactive graphs, tables, and virtual 3D-models of molecules and crystals with the option of displaying the layout of electrostatic potential (electronic density) on the surface of molecules.

Units also contain a series of exercises on various difficulty and interactivity levels for current examination of understanding with multiple possible answers and one correct answer and text completion exercises. Applets and didactic games, with a high level of interactivity, are also used. In elements with a high level of interactivity we also include interactive 3D models of molecules and crystals, which are one of the more significant achievements of chemistry e-textbooks, because a well-developed visual presentation is of key importance for better understanding of abstract chemical and science concepts, Figure 1.

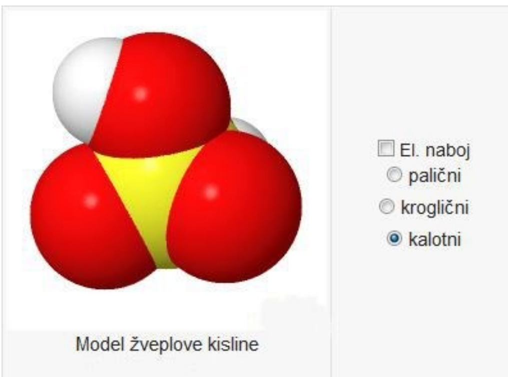

Figure 1: 3D model of sulfuric acid molecules with the option of displaying electrostatic charge and other various options of displaying atoms. The model can be moved in virtual space.

Interactive 3D models of molecules allow submicroscopic visualization of structures and thus present three-dimensional picture of the structure of molecules, the length of bonds and angles between atoms. They give an insight into the distribution of electrondensity on the molecules' surface and facilitate the understanding of compounds' reactivity. Some e-textbook contents are also designed in such a manner that students recognize certain regularities on their own via interactive elements, Figure 2.

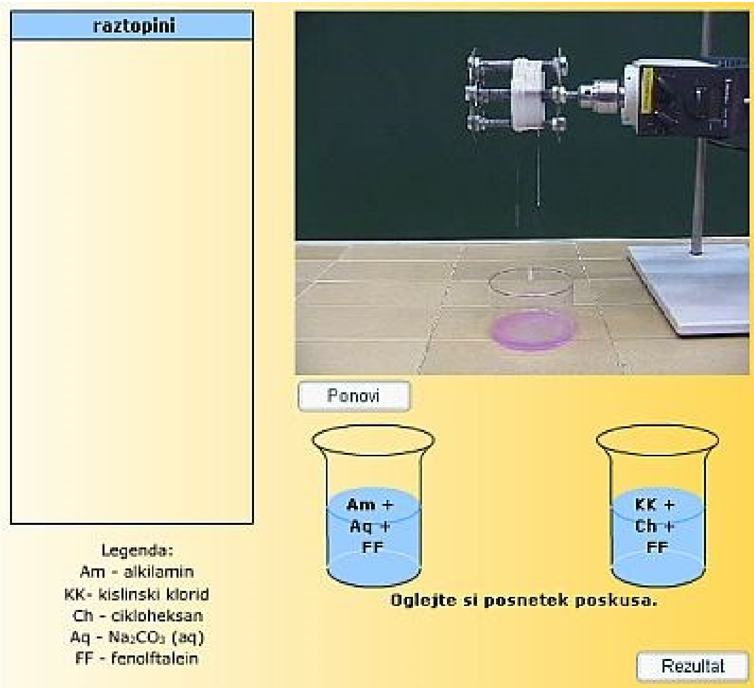

*Figure 2: Successfully derived nylon synthesis in the virtual laboratory **

* Students in the virtual laboratory independently select reagents, prepare and mix solutions and thus explore the steps of nylon synthesis.

First experiences in using the chemistry e-textbook

In the school year 2013-14 the project "Testing and use of e-contents and e-services" is in progress. The results of this project will be known at the end of the project. At Gimnazija Ptuj (secondary school) we have decided to start using chemistry e-textbooks in 1st grade. The students have tablets computers available in chemistry class and also at home for studying. First experiences show, that each planned period is hard to execute due to technical difficulties, such as unavailability of network. We will be able to resolve this issue when the students will be able to transfer e-textbooks to their portable devices. One issue is also the difficulty to control the work of 32 students. Internet access is very attractive for those less motivated students, who quickly forget about chemistry and start browsing their favourite web sites or chat rooms. However, the students of 1st grade of secondary school did not have this issue so far, because they were attracted to the work in the textbook. A positive experience is particularly the fact that students gladly do all the exercises and make a considerable effort to make their answers as green as possible (correct). After a half of school year of e-textbook use in chemistry class we asked the students to give good and bad qualities of e-textbook use. 27 out of 32 students anonymously wrote their opinion on e-textbook use. Their overall opinion is positive.

As an advantage of e-textbook use they state:

– All textbooks are on a tablet computer, which makes the school bag smaller and easier to carry.
– A transparent table of contents, transparent textbook, transparent summary content.
– Learning with e-textbook is more attractive.
– Due to moving pictures, applets, 3D models and animations the students have a better idea of learning contents.
– Many interactive exercises and examples enable knowledge consolidation.
– When solving exercises they receive immediate response and also a clue.
– The E-textbook is available everywhere, at home, at school, on a journey. Students themselves recognize that such a textbook is easier to update and repair.

As disadvantage of e-textbook use the students state:

– Occasional internet unavailability or poor internet connection, which slows down the work with e-textbook.
– The frequent need to charge the batteries of the tablet.
– Some find it easier to study from a classic textbook, because it is easier to thumb through it, easier to mark the pages and the textbook is right at hand. When working with the e-textbook the computer or tablet must be turned on first.
– When working with e-textbook some indicate the problems with watching the screen.
– The students also warn that they quickly succumb to using other web sites, while learning and also in class.

Current experience in the use of e-textbooks is positive. The possibilities offered by the e-textbook are useful for teachers when they explain the concepts and also for students, because they consolidate those concepts and understand them more easily. It is up to a teacher to what extent they will use and exploit the e-textbook. And the students have an option to read about and study chemistry in an alternative way, with more independent activity.

Conclusion

If we are judging e-textbooks only as textbooks and compare them to printed versions of textbooks for chemistry, we can claim that the project has reached its set objectives. All the elements, which are static or not included in classic textbook, are dynamic and some also interactive in the electronic version. Instead of mere images and descriptions of experiments the pupils and students can observe videos of experiments, instead of images of molecules and crystals they are able to use interactive virtual models, instead of graphic presentations of reaction schemes these are presented as animations. A significant advantage of e-textbooks over printed versions is interactive exercises for current assessment of understanding of chemical concepts and processes, which direct and encourage the learning process. We are certain that the wide availability of e-textbooks will encourage their use at first, because it will be something new for the students, something adapted to their enthusiasm in modern communication technology, such as tablets, smart phones, i-Pads and similar. However experience show that the initial excitement will wear off sooner or later, because according to our research, textbooks, electronic or printed, are a less popular learning material and that the teacher's explanation is still the most convincing for students (Vrtačnik, Juriševič and Ferk Savec, 2010). The fate of the e-textbooks in the future will, therefore, first and foremost depend on teachers and their resourcefulness in including e-units in chemistry class.

Nevertheless we also have to be realistic and admit that the quality of multimedia elements in e-textbooks and their didactic execution do not fully follow the development on this field in the world. Interactivity of e-textbooks is ensured, predominately, by the use of the eXeCute program. Multimedia elements are generally not interactive, because they do not enable interference into the processes of animation, simulation, molecule modelling, shifting the course of the process and do not support knowledge integration as in e.g., programme Molecular Workbench, Visual Interactive Simulations for Teaching end Learning Science (http://mw.concord.org/modeler/download.html). Also the mere observation of processes does not represent a basic didactic progress, if the user does not have the possibility of independent experiment planning, setting hypothesis and their testing. Such an approach is enabled by virtual chemistry laboratories, which are preliminary preparations for laboratory work or even a substitution to the real work in the wet laboratory. According to the fact that there is less and less experiments conducted in the chemistry class, especially quantitative ones, those virtual chemistry laboratories would be a welcomed completion of the chemistry class. The students would not gain any experimental skills with this, but they would develop the elements of a research approach and thus higher cognitive skills.

As editors we hope that the search and development of new options of ICT use in schools will not end with the "E-učbeniki" project. Perhaps it would be wise to join knowledge and experience and prepare a program similar to the "Molecular Workbench" or the "virtual laboratories for science" (Jones and Tasker, 2002). There are still many challenges; we must only ensure financial means. We have to be aware that the investment in youth is also investment in our common future.

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Evaluation of mathematics i-textbooks at elementary and secondary level

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The paper presents the results of six pedagogical experiments evaluating i-textbooks for mathematics in 4th and 5th grade. The evaluation was carried out on various mathematical topics in the following areas: arithmetic (numeric expressions with parentheses), geometry (perimeter), measurement (weight and time; relationships between measurement units) and data processing (data collection and presentation). 204 students were included in the survey (N = 204). The results demonstrate that the achievements of pupils in all experimental groups surpass the performance of students in comparable control groups. In some groups, the difference is statistically significant. Additionally, the results of one pedagogical experiment (N = 49) show that the knowledge of students who have the applied i-textbook is superior to the mathematical achievements of the pupils in the control group in both declarative and procedural as well as conceptual and problem solving-types of knowledge.

Key words: mathematics instruction, i-textbooks, e-learning materials, interactivity, pedagogical experiment

Introduction

Several studies confirm the assumption that on average students, who have access to a computer at school, derogate from students who do not. The educational achievement of students due to the use of information and communication technology (ICT) does not change (improve), the benefits of ICT are visible especially in terms of increased motivation and individual learning (PISA 2006; ESRI 2007; TIMSS 2007). Some research in the field of mathematics in Slovenia have empirically already confirmed a positive effect of e-learning media on students of mathematics (e.g. Antolin, 2009). The primary purpose of e-learning material developers, which were the basis of i-textbooks, still remains the gaining of mathematical knowledge, i.e. cognitive aspect (Lipovec, Kobal and Repolusk, 2007).

By introducing ICT in teaching, we encounter many different problems. This is particularly true for students in the primary level, since they need a lot of support and supervision. The classrooms are often equipped with just one computer with limited software and limited dedicated to development of skills required for the use of a computer (Higgins, Packard, and Race, 1999, p. 5). It should be emphasised that the "teacher training and regular updating of their ICT knowledge and skills is very important in integrating technology into the daily educational practice" (Japelj and Čuček, 2000, p. 113). We are faced with a problem where we have many options to integrate ICT into teaching on one hand, and teachers who are afraid to apply these new technologies on the other hand. Problems also lie in poor ICT equipment of schools and too little time for the introduction of new content, etc. The market also provides a huge amount of new e-learning materials, which are not necessarily qualitative or in accordance with the curriculum.

General guidelines for teaching with e-learning materials do not differ from the general guidelines for teaching with traditional teaching materials (printed materials). Both are based on the choice of an appropriate educational approach, which depends on educational goals we want to achieve (Repolusk, 2009, p. 193).

In this paper we will define an i-textbook as an e-textbook with a high amount of interactive elements with a high level of interactivity. The concept content is defined with a relationship between a concept and a conceptual applet. The essential difference between e-textbooks and i-textbooks is in the level interactivity, which is defined (Repolusk, Zmazek, Hvala and Ivanuš Grmek, 2010) as a characteristic of a controlled process of communication, that contains at least two different return loops that can potentially be executed several times.

An I-textbook, as a source of education, poses a new challenge for teachers. Since it has not been evaluated in the Slovenian school environment, a verification of effects on a cognitive domain of students is necessary. The goal of this evaluation is to measure the impact of an i-textbook for mathematics on the level of knowledge in school mathematics.

Methodology

We carried out a one-factor pedagogical experiment with one modality (using an i-textbook for mathematics). The experimental and control group were given an introductory and a final test of knowledge. Differences in knowledge and attitudeswill be measured by the methods of descriptive and inferential statistics. Table 1 illustrates a detailed sample structure and units used in the i-textbook.

Pedagogical experiment	Class	Set/content	N Experimental group	N Control group	N Combined
A	4.	Arithmetic - numeric expressions http://eucbeniki.sio.si/test/iucbeniki/mat4/106/index.html http://eucbeniki.sio.si/test/iucbeniki/mat4/107/index.html	23	26	49
B	5.	Other content - Data processing http://eucbeniki.sio.si/test/iucbeniki/mat5/749/index.html http://eucbeniki.sio.si/test/iucbeniki/mat5/750/index.html http://eucbeniki.sio.si/test/iucbeniki/mat5/751/index.html	22	20	42
C	5.	Geometry - Perimeter http://eucbeniki.sio.si/test/iucbeniki/mat5/759/index.html	20	19	39
D	5.	Measurement - Quantity http://eucbeniki.sio.si/test/iucbeniki/mat5/707/index.html	17	17	34
E	4.	Measurement - Mass, time http://eucbeniki.sio.si/test/iucbeniki/mat4/555/index.html http://eucbeniki.sio.si/test/iucbeniki/mat4/86/index.html	20	20	40
Combined			102	102	204

Table 1: Sample structure and units used

In this pedagogical experiment we used e-learning materials, which are a part of an i-textbook developed in the framework of the project E-textbooks for science classes in primary school (2011-2014). Exercises for the introductory test were developed on the example of TIMSS 2003. The final test was developed to measure the content being taught in schools and to ensure objectivity it was formed by the textbooks for 4th and 5th grade (Japelj Pavešić and Keršić, 2008; Japelj Pavešić, Keržič and Kukovič, 2009), which were not used in any of the selected schools. In the experiment A we focused on types/taxonomies of knowledge, which are particularly effectively developed by i-textbooks. To this end designed the exercises in the finaltest to demonstrate the following types: declarative knowledge, conceptual knowledge, procedural knowledge and problemknowledge.

The classes in the experimental group ranged from 5-9 hours, depending on the size of an evaluated set. The control group has been working in the same time the layout, but the teacher used resources she would otherwise use too. The teachers of the experimental group were students of the Elementary education programme at the University of Maribor and in the control group their class teachers. As an essential limitation in research we must highlight the poor equipment in schools, which were included in the evaluation, and different teachers for the experimental and control group. None of schools were equipped with tablets and even though they had available computer classrooms, several issues with the Internet occurred. We are also aware of the fact that teachers have an influence on the atmosphere and openness of students to at least the same extent as an impact of a certain type of a textbook (printed/interactive).

Experiment date	Experimental group
Day 1	A 20 minute introductory test 25 minutes of learning content: tabs: Numeric expressions 45 minutes of learning content: tabs: Write down a calculation, equivalent operations Aids: projector, Internet connection, interactive whiteboard
Day 2	45 minutes learning content (computer classroom) Tabs: Numeric expressions/Exercises (selected exercises)
Day 3	45 minutes of learning content Tabs: Exercises (6, 9, 13 and 14) Bracket, Write down a calculation, Solve a calculation, Calculation order Aids: projector, Internet connection, interactive whiteboard

Day 4	45 minutes learning content (computer classroom) Tabs: Bracket/Exercises
Day 5	45 minutes of learning content Assignment review Bracket/Exercises (2, 9, 10, 13 and 14) Tabs: Numeric expressions/Summary Brackets/Summary
Day 6	A 45 minute final exam

Table 2: Pedagogical experiment - timetable (group A)

In the following section we will present the teaching materials used in the pedagogical experiment B and describe the course of the lessons. Due to significant deviations in the work process compared to the planned process in a classroom, we decided to provide a detailed description of this experiment. Because the school did not have a working Internet connection, a guided training and consolidation of knowledge was carried out with the aid of a projector instead of differentiated lessons provided by the levelling exercises in an i-textbook.

An extended lessons time, with the use of an i-textbook in the pedagogical experiment B, can also be explained with the following assumption, which is based on research formulated by Mason (1995, Povey and Ransom, 2000, p. 55): "Animated images may, in specific cases, reduce the time required for an illustration and presentation of a specific mathematical idea, but can on the other hand, extend the time for the construction of new knowledge. In other words: electronic displays can improve learning, but are still not less time demanding." In the light of this finding, deviations from the planned time frames are expected with the use of i-textbooks. For this reason, the results of this group may show improvement of knowledge after a long period of time. This could also explain better results of students in the final examination of the experimental group B in relation to the control group, which showed no statistically significant differences due to the need for an extended time frame.

In experiment B, students worked through three major topics:

- counting (tally marks, counting with dots and lines), data (numeric and descriptive), data editing (alphabetic, numeric type), sorting data;
- tables, display with columns (a pictorial representation), displaywith rows;
- a pie chart, parts of a whole, a whole, data reading.

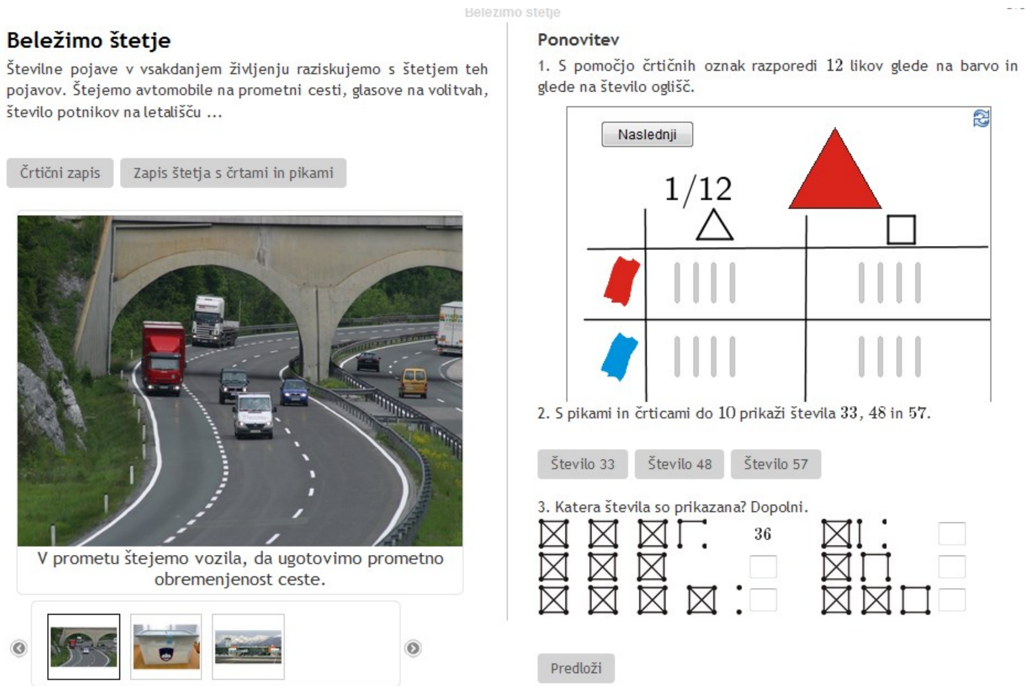


Figure 1: 1st lesson: Counting (Source: http://eucbeniki.sio.si/test/iucbeniki/mat5/749/index.html)

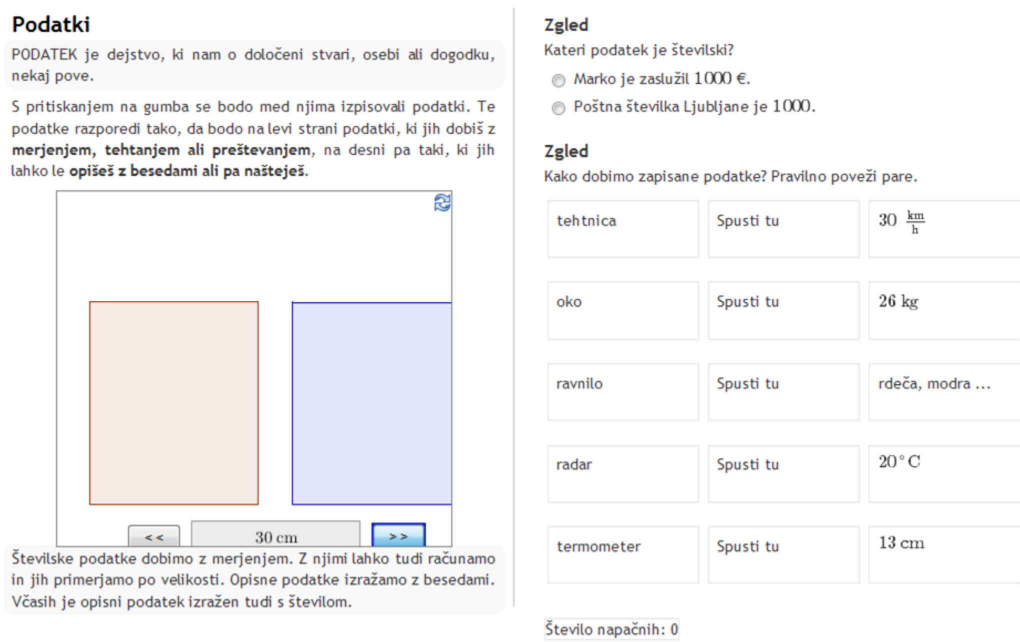


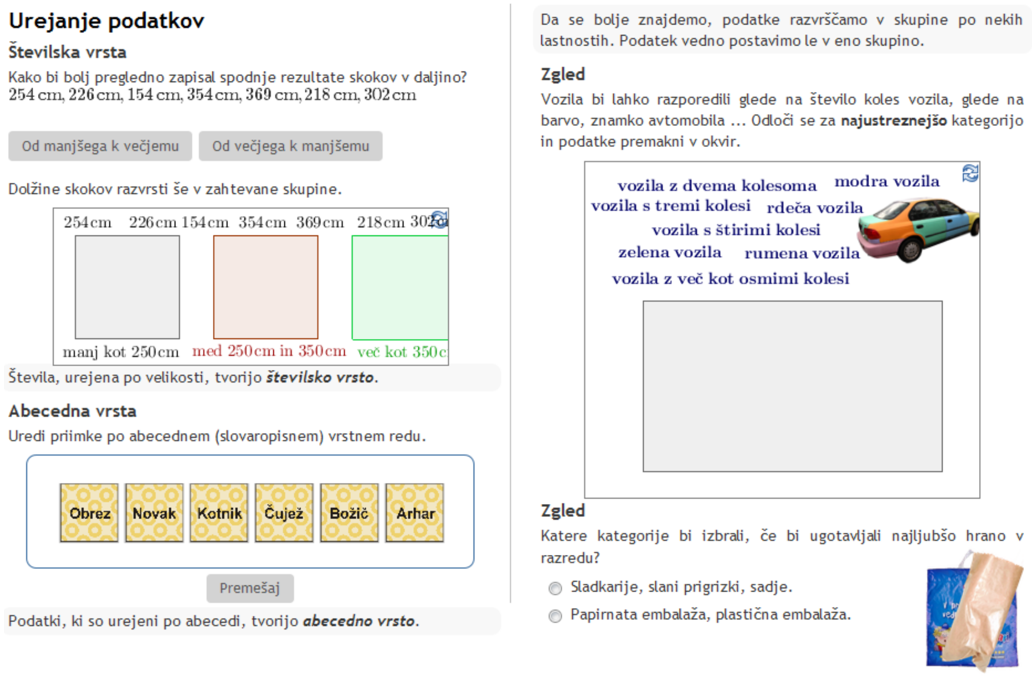
Figure 2: 1st lesson: Data (Source: http://eucbeniki.sio.si/test/iucbeniki/mat5/749/index1.html)

In the introduction phase of a lesson we discussed with the students what they see in the picture (traffic) and what would be the easiest way to count traffic. The most frequent answer was to count with numerals one, two, three, etc. and then someone proposed to count with tally marks. A teacher (a student of the Primary education programme) showed an example of an easier way to count large amount of data (with tally marks, lines and dots).

Students completed exercises in the e-learning materials. According to the teacher, students did not have any problems. What followed was a guided conversation about categorisation of data: descriptive and numeric. They tried to solve exercises in the i-textbook Source: http://eucbeniki.sio.si/test/iucbeniki /mat5/749/index1.html but they caused them a few difficulties. This categorisation is rarely found in conventional sources and is considered to be a difficult content.

In a guided discussion, students familiarised themselves with the concept of numeric and alphabetic types and sorted data by common properties (Figure 3). Although it was planned, that the next five pages of the i-textbook would be included in the first lesson, they ran out of time.

At the beginning of the second lessons they repeated what was learned in the previous lesson and continued with e-learning materials and sorting of data. They assessed the exercise that required sorting of data by classes (Figure 4). A teacher then explained, with the method of discourse, that when sorting numerical data we can often help ourselves with sorting in classes of same size, which the students then carried out in practice with the exercise in the top right corner (Figure 4). For repetition of knowledge they completed exercises below. Students had several difficulties with sorting in classes.. Even later on, when they were solving exercises, the majority of students still did not grasp the concept. When they completed and exercise they were able to describe the solving process, but when they met with a similar exercise and different data, the transfer of knowledge did not take place, which leads to a conclusion that this problem-knowledge did not develop. They solved more exercises. They solved exercises that were not used later for training levels.



Urejanje podatkov

Številska vrsta

Kako bi bolj pregledno zapisal spodnje rezultate skokov v daljino?
254 cm, 226 cm, 154 cm, 354 cm, 369 cm, 218 cm, 302 cm

Od manjšega k večjemu | Od večjega k manjšemu

Dolžine skokov razvrsti še v zahtevane skupine.

254 cm 226 cm 154 cm 354 cm 369 cm 218 cm 302 cm

manj kot 250 cm | med 250 cm in 350 cm | več kot 350 c

Števila, urejena po velikosti, tvorijo ***številsko vrsto***.

Abecedna vrsta

Uredi priimke po abecednem (slovaropisnem) vrstnem redu.

Obrez | Novak | Kotnik | Čuješ | Božič | Arhar

Premešaj

Podatki, ki so urejeni po abecedi, tvorijo ***abecedno vrsto***.

Da se bolje znajdemo, podatke razvrščamo v skupine po nekih lastnostih. Podatek vedno postavimo le v eno skupino.

Zgled

Vozila bi lahko razporedili glede na število koles vozila, glede na barvo, znamko avtomobila ... Odloči se za **najustreznejšo** kategorijo in podatke premakni v okvir.

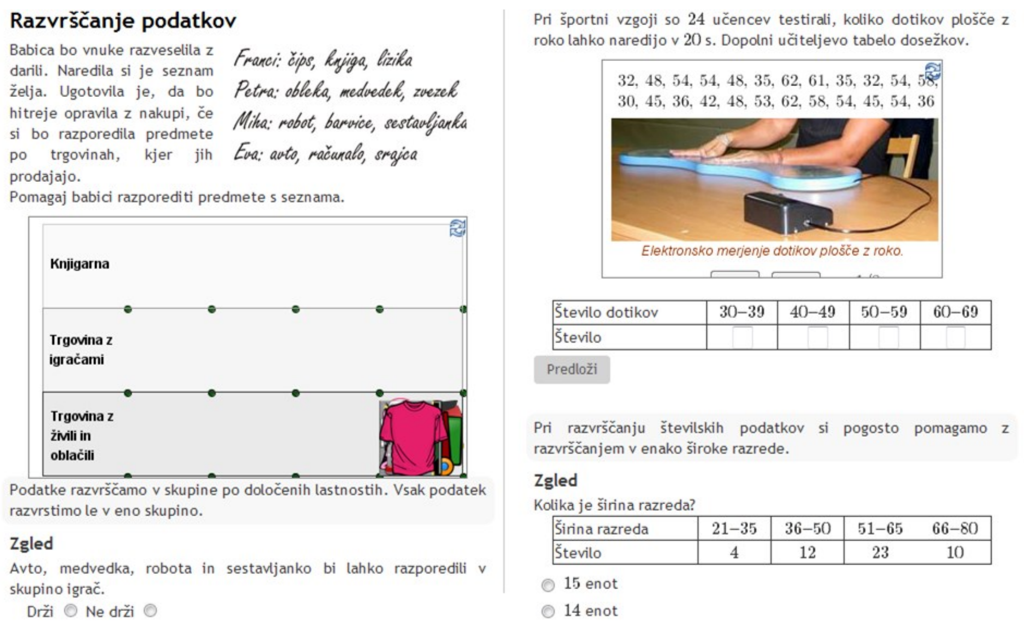
vozila z dvema kolesoma
modra vozila
vozila s tremi kolesi
rdeča vozila
vozila s štirimi kolesi
zelena vozila
rumena vozila
vozila z več kot osmimi kolesi

Zgled

Katere kategorije bi izbrali, če bi ugotavljali najljubšo hrano v razredu?

- Sladkarije, slani prigrizki, sadje.
- Papirnata embalaža, plastična embalaža.

Figure 3: 1st lesson: Editing data (Source: http://eucbeniki.sio.si/test/iucbeniki/mat5/749/index2.html)



Razvrščanje podatkov

Babica bo vnuke razveselila z darili. Naredila si je seznam želja. Ugotovila je, da bo hitreje opravila z nakupi, če si bo razporedila predmete po trgovinah, kjer jih prodajajo.

Franci: čips, knjiga, lizika
Petra: obleka, medvedek, zvezek
Miha: robot, barvice, sestavljanka
Eva: avto, računalo, srajca

Pomagaj babici razporediti predmete s seznama.

Knjigarna
Trgovina z igračami
Trgovina z živili in oblačili

Podatke razvrščamo v skupine po določenih lastnostih. Vsak podatek razvrstimo le v eno skupino.

Zgled

Avto, medvedka, robota in sestavljanko bi lahko razporedili v skupino igrač.

Drži ○ Ne drži ○

Pri športni vzgoji so 24 učencev testirali, koliko dotikov plošče z roko lahko naredijo v 20 s. Dopolni učiteljevo tabelo doseškov.

32, 48, 54, 54, 48, 35, 62, 61, 35, 32, 54, 58, 30, 45, 36, 42, 48, 53, 62, 58, 54, 45, 54, 36

Elektronsko merjenje dotikov plošče z roko.

Število dotikov	30–39	40–49	50–59	60–69
Število				

Predloži

Pri razvrščanju številskih podatkov si pogosto pomagamo z razvrščanjem v enako široke razrede.

Zgled

Kolika je širina razreda?

Širina razreda	21–35	36–50	51–65	66–80
Število	4	12	23	10

- 15 enot
- 14 enot

Figure 4: 2nd lesson: Sorting data (Source: http://eucbeniki.sio.si/test/iucbeniki/mat5/749/index3.html)

In the 3rd lesson students reiterated how we label diagrams, with the help of the exercise on mountain height (Figure 5). For the purpose of repetition of previous lesson students, in addition to this page, solved exercises where a student drew a spreadsheet with information on height, shoe size and favourite colour for six classmates . It turned out that this additional exercise ruined the time frame for planned activities, which resulted in failure to meet the expected mathematical goals.

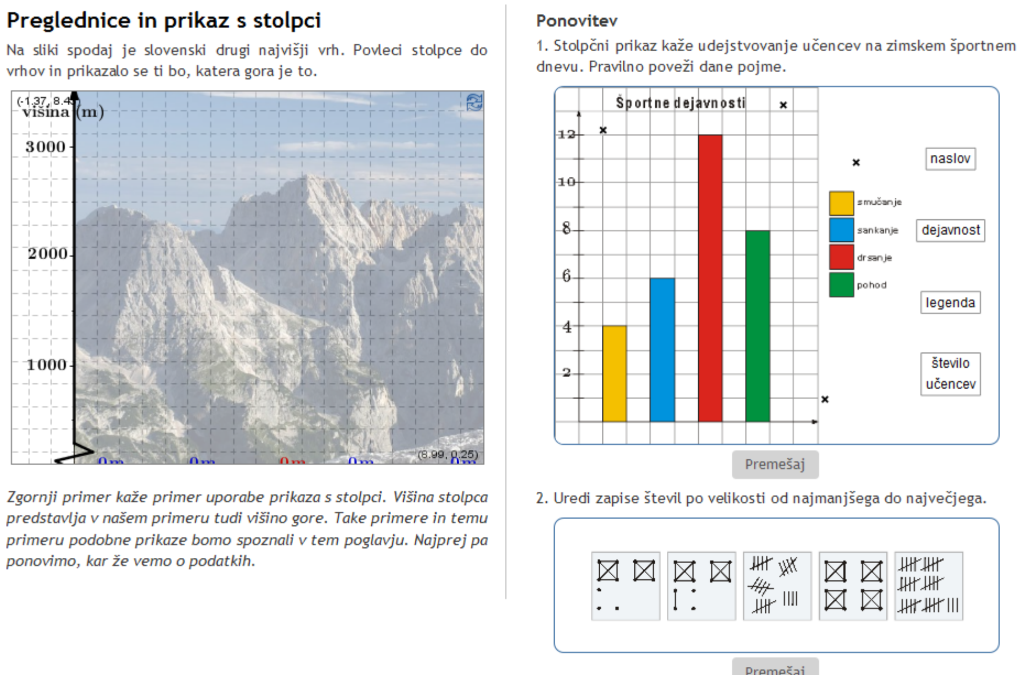


Figure 5: 3rd lesson: Display with columns (Source: http://eucbeniki.sio.si/test/iucbeniki/mat5/750/index.html)

This (fourth) lesson students tackled the spreadsheets immediately. The Love struck couples exercise (Figure 6), which falls within the scope of logic, and uses spreadsheets as a tool for solving exercises, caused expected problems for students.

Students solved an exercise with a pictorial display. Students first tried to solve it by themselves, then the whole class looked at what certain figures represent (Figure 7). They needed additional clarification. They displayed data from the image with a horizontal bar graph. This did not cause any problems to students. For a demonstration of a display with rows they used another assignment in which data is again given with a pictorial display. Students needed additional information about the significance of symbols and after that the use of a vertical bar graph did not cause any problems.

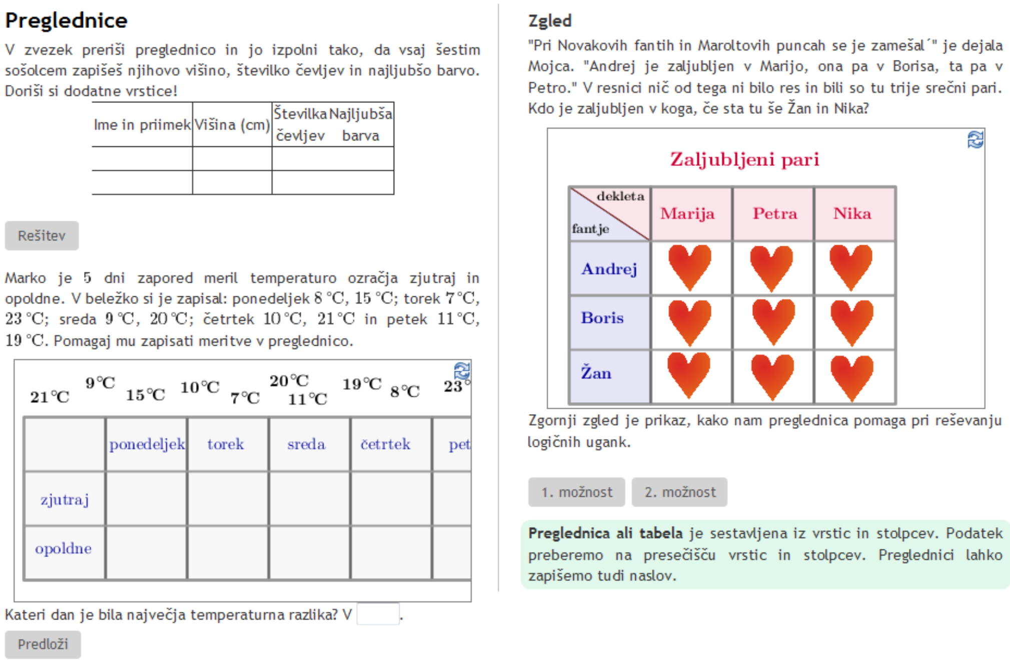


Figure 6: 4th lesson: Spreadsheets and Display with columns (Source: http://eucbeniki.sio.si/test/iucbeniki/mat5/750/index1.html)

186

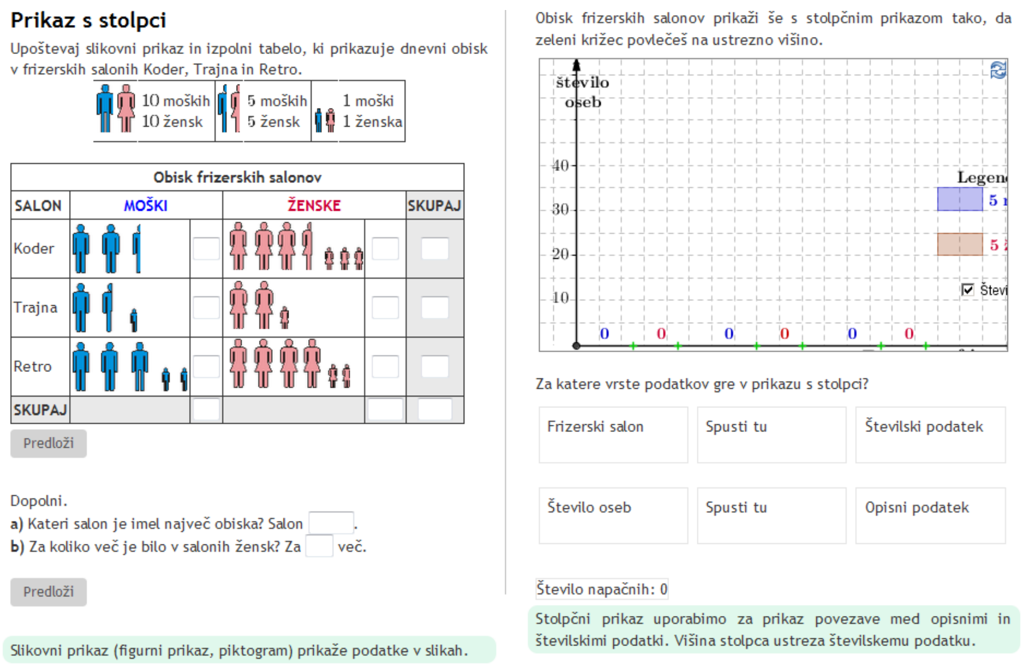


Figure 7: 4th lesson: Display with columns and rows (Source: http://eucbeniki.sio.si/test/iucbeniki/mat5/750/index2.html)

The 5th lesson was aimed at consolidating the processed units and was held in a computer classroom. Students were given learning material with instructions for consolidation on levels marked with the same colours then the ones in the i-textbook. They worked in pairs. Because they consolidated lessons of two units, they needed a worksheet to guide them. Medium level, e.g. solved all the blue exercises from both processed units (Counting and Spreadsheets and display with columns). In Figure 8 we see blue (medium level) and red (maximum level) exercises.

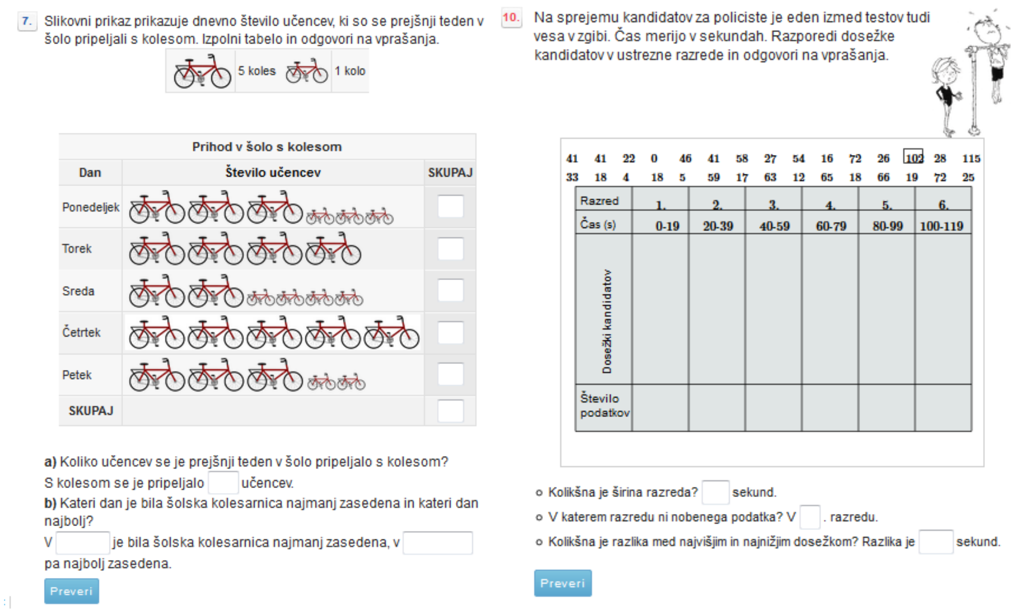


Figure 8: 5th lesson: A differentiated consolidation (Source: http://eucbeniki.sio.si/test/iucbeniki/mat5/750/index8.html)

In the 6th lesson students began working on specific activities, with a Pie chart (Figure 9) as a motivation. They drew around the edge of a plate on a poster. They stacked 36 candies around that line by colour. The boundaries between colours were marked. The candy and the plate were then removed and a pie chart was drawn. Then the students solved an exercise to repeat fractions and proceed with a guided solving of exercises from the unit. A teacher, in reflection, pointed out that the content was extremely difficult and it took her a lot of time to prepare for it. Response of students and their knowledge has positively surprised her.

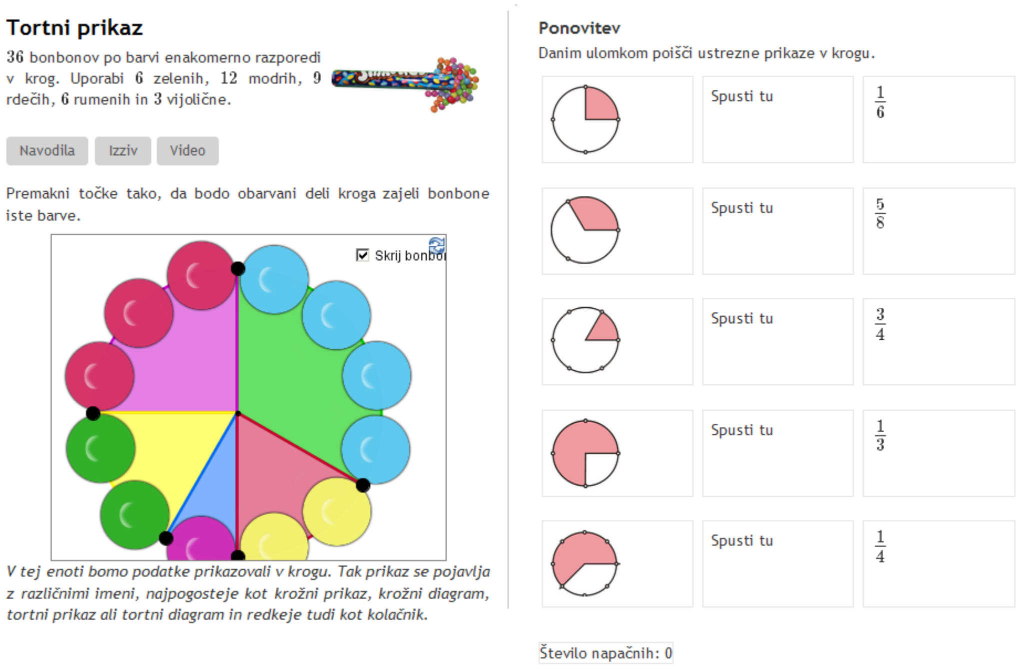


Figure 9: 6th lesson: Pie chart (Source: http://eucbeniki.sio.si/test/iucbeniki/mat5/751/index.html)

The last (seventh) lesson began with a repetition and a summary of previous lessons and continued with solving exercises. Because they did not have an available computer classroom (problems with the Internet), they solved exercises from the e-learning materials. The motivation of students slightly dropped, because they were looking forward to working individually on a computer. For motivation, the teacher organised a "competition" of boys versus girls.

Results and discussion

As shown in Table 3, the introductory test shows similar results with no statistically significant differences between the experimental and control group. In experiments A, B and D, the effect was determined on the base of inferential statistics and in experiments C and E on descriptive statistics. Each of these educational experiments is a program implemented by a different student of Primary education and the students' competences in the field of statistical processing influenced the level of statistics produced. Even though there is no data showing inferential statistics, a comparison of achievements in groups B and D allows us to draw conclusions about groups C and E. From the data of the experiment B we can conclude that the introductory test knowledge is equal for experiments C and E, because the performance of both groups is almost identical.

This means that both groups have equal pre-knowledge and that appropriate conditions were set for the experiment. To difference in achievement rating is a result of the fact that TIMSS 2003 exercises are designed for 4th grade students, but because they are standardized, we used them for 5th grade students.

Pedagogical experiment	Experimental group	Control group	
A	47 %	53 %	χ^2=0,754, P=0,686
B	76 %	78 %	t=1,181, P=0,858
C	76 %	77 %	no data
D	73 %	74 %	t=0,312, P=0,757
E	66 %	65 %	no data

Table 3: Introductory test results

On the final exam all experimental groups achieved slightly better results than the control groups. Achievement result is significantly better for experiment D (t = -2.210, P = 0.034), in experiment A we see a trend of statistically significantly better achievement rating (χ^2 = 4.738, P = 0.094), in experiment B there is no statistically significant difference between students of the experimental and control group (t=-0.837, P=0.408). The experimental group did achieve better results, but the difference is not statistically significant. In the case of groups C and E, the level of descriptive statistics shows better achievement results for the experimental group, however, no conclusion can be drawn on statistical significance.

Pedagogical experiment	Experimental group	Control group	
A	73 %	66 %	χ^2=4,738, P=0,094
B	93 %	89 %	t=-0,837, P=0,408
C	72 %	59 %	no data
D	61 %	50 %	t=-2,210, P=0,034
E	53 %	63 %	no data

Table 4: Final test results

There were no statistically significant differences in knowledge in experiment B, which could be a result of the nature of the mathematical content (data processing) or prevailing presentation of concepts in this content (diagrams). Uesaka and Manalo (2008) summarize some recent studies on diagrams as a tool for problem-solving and communication. They do not define the term diagram, but from the methodological part of the research, it is evident that these are visual representations of a static type (graph, table, sketch, etc.). In their study, they analysed 5 days of classes for 59 students in the 8th grade of primary school. Even though many studies show that the use diagrams is one of the most effective strategies in solving problems and that the empirical research supports the use of diagrams as effective mediators in the implementation of various procedures (Ainsworth and Loizou, 2003; Larkin and Simon, 1987; Mayer, 2003; Schoenfeld, 1985, Uesakaand Manalo, 2008, p. 1711), Uesaka and Manalo point out the fact that many students do not know how to use diagrams spontaneously despite an extensive exposure to opportunities of appropriate use of diagrams. The results of this study also suggest that the display of diagrams alone is not sufficient to encourage a spontaneous use of diagrams as a tool for solving problems: teachers must enable additional opportunities to use diagrams and peer consultation when solving problems. On the other hand, Kolloffel, Eysink, de Jong, and Wilhelm (2009), with their own research suggest the possibility, that the efficacy of a demonstration format also depends on the mathematical content and students' previous experience with the content. They researched the effect of different presentation formats (static diagrams - pictures, text, algebraic notation, combination of text and algebraic expressions, combinations of diagrams and algebraic expressions) in learning combinatorics and probability in a computerized environment. Although Rogers (1999, Kolloffel et al., 2009, p. 514-515) previously considered that interactive representations reduce the scope of cognitive activities of "lower levels" and enable students to focus on cognitive activities of "higher levels", the results have shown that learning with tree diagrams in a computerised environment led to worse results in solving mathematical problems and lead to an increased scope of cognitive activities. The best results were achieved by students who studied using a combination of text and equations (algebraic expressions). Tabachneck-Schijfoveand associates (1997, Kolloffel et al., 2009, p. 515) tried to analyse this result and they came to a conclusion that diagrams serve as a lever for access to information in the long-term memory and can help reduce the load on the experts working (short-term) memory and thus release cognitive resources, which can then be focused toward interpretation and problem solving. Authors highlight some further consequences of this conclusion:

> *"We conclude that diagrams may be more suitable for people, who already possess relevant conceptual scheme of the content (e.g. for mathematics teachers) and use diagrams as a mnemotechnical tool. Such an interpretation also suggests that tree diagrams are less appropriate for students to deduct appropriate steps of justification and conclusions, which are implement implicitly and require advanced knowledge of diagrams. This may prove to be an issue for the use of diagrams in content such as combinatorics and probability in which problem-solving requires a*

proper sequence of steps of justification and reasoning, but at the same time it provides an advantage for the algebraic text and text combination. In a text format presentation students are guided by hand, step-by-step, through explicit sequence of steps of reasoning, written in an everyday language, which is then followed by equations or algebraic notations in the same structured sequence (Kolloffel et al., 2009, p. 515)."

The research report, however, does not explain how authors interpreted the term interactivity, which is, in our opinion, a key element: they examined the efficacy of demonstration formats (diagrams, text, symbolic algebraic notations), which are by their nature static, but were integrated in the software with a presentation on a computer. This is where we encounter a problem of a correct definition of an interactive medium, which we tried to resolve with a definition of an e-textbook and an i-textbook. In spite of this ambiguity, the results of Kolloffela et al. are valuable for the examination of the i-textbook role, where identical presentation formats are included, only in an actual interactive form. This raises, by our assessment, an important research question: is the use of interactive elements an effective way to present all mathematical concepts and if not, is it possible to identify common features of mathematical concepts, where the use of other demonstration formats is more effective?

The Slovenian school system is characterised by the fact that there is too much emphasis on procedural and declarative type of knowledge and not enough on conceptual and problem knowledge (Japelj Pavešić, Svetlik and Kozina, 2013). We are therefore very surprised by the results. We discovered that the experimental group had better results in all four types of knowledge, but not statistically significant in the procedural type of knowledge. There is no statistically significant difference between two groups in procedural type of knowledge (χ^2 = 1.725, P = 0.422). In declarative, conceptual and problem knowledge, the experimental group was statistically significantly better than control group (χ^2 = 6.295, P = 0.043 ; χ^2 = 10.025, P = 0.007 and χ^2 = 6.613, P = 0.037).

Conclusion

Evaluation of an i-textbook showed that the use of an i-textbook for teaching mathematics in 4th and 5th grade of primary school yields positive results on the cognitive field. We can also assume that the impact of the use of an i-textbook on mathematical knowledge is relatively independent from teaching of mathematical content, as our research confirmed a positive effect on topics of Measuring, Arithmetic and Other content. If we add the results of previous evaluations (Antolin and Lipovec, 2010) made with e-materials for geometric content in 6th grade, which were carried out by a similar group of authors as i-textbooks, we can see that all fields of mathematics are covered, except algebra. The limitations of this evaluation are reflected in the fact that it covers only the second third-year and that the sample was not representative. Despite these limitations we believe that we can confirm our hypothesis, that, in observed examples, i-textbooks have a positive influence on mathematical knowledge of students.

Further the findings confirm he efficacy of blended learning. In lessons, where students worked only with e-teaching materials (usually consolidation trough generated exercises), students lost motivation towards the end of the lesson, however, where made an introduction to these lessons without a computer, and then included the use of a computer, students remained focused until the end of a lesson.

At the end we would like to highlight the impact of an i-textbook on different types of knowledge. We believe that these attributes are not only a result of the medium (e-form), but also a result of a specifically designed methodical approach. Our reasoning is in line with the findings of Ameisa (2006) and Clark and Mayer (2008), who stress that the quality and presentation of e-learning content are a key factor for effective learning, where clearness and interactivity are not sufficient by themselves.

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Modelling and mathematics i-textbooks at elementary and secondary level

Alenka Lipovec, Jožef Senekovič

In this paper we present the use of i-textbooks in the case of modelling. First, findings about modelling as problem-based learning and teaching approach are summarized and differences in this approach in high school and elementary school are highlighted. Modelling is already an established educational approach in Slovenian high schools, but it is still in its initial stages in the new elementary and secondary schools curricula. The remainder of the paper is devoted to some modelling examples that can be found in mathematics i-textbooks. Through examples, we explain and illustrate the basic features of modelling in a computer-based environment at primary level (1st to 5th grade) and secondary level (6th to 9th grade). We argue that i-textbooks are well-suited for this approach because of the greater possibility of visualization, i.e., simulations of real situations than in traditional textbooks.

Key words: i-textbook, modelling, complex systems, mathematics education, contextualization

Introduction

We can find a wide range of real life exercises, real situations and problems in an i-textbook. Students must use mathematical knowledge to solve a contextualised problem. When solving problems in a real context, students integrate knowledge from different mathematical areas (Učni načrt za matematiko (eng. Mathematics Curriculum), 2011). Problems become meaningful and useful for students. One of the options to address these problems in a real context is modelling. Modelling is an active experience of mathematics (Buchter and Leuders, 2005), in which students, through various activities, experience mathematics as a creative process, not as a reference to facts. Modelling is describing real situations with mathematical concepts. With a developed model, we can predict events and results in different areas of life (social, economic, sports, etc.). In a strict sense we can interpret modelling as development of physical models, which can then be described with mathematical concepts. But in a wider sense it is a process that leads us from real situations to a mathematical model and "back" (Kmetič, 2010).

We are entering a phase of information society. Such a society solves problems in development of industrial production by introducing robots, mass introduction of computers and violent development of science and education. Information society stresses the importance of educational system informatisation in the area of introducing computers and other educational technology. Schools that are well equipped with technology can provide a more versatile educational development of students then schools that do not have these options (Gerlič, 2000).

An important parameter, which may affect the work of students in activities of modelling, is the presence of technology. Christou, Mousoulides, Pittalis, and Pitta-Pantazi (2005) report that the use of tools for dynamic geometry can help solve problems for future teachers. They also believe that modelling in a virtual environment can provide an insight into conceptual understanding. It seems that ICT can contribute to the skill of modelling with primary school students. In some studies, a virtual environment enabled 12-year old students, who had no previous experience with modelling, a better visualization in development of ideas about a bottle of a known drink (Mousoulides, Pittalis, Christou, Boytchev, Sriraman and Pitta, 2007) or in the search for a solution for water supply with five parameters (price of water, the need for water, capacity of tankers, fuel price and port capacity) (Mousoulides, Chrysostomou, Pittalis & Christou, 2009). In the first case, the technology helped them with design and in the second case in determining routes on a map.

Modelling

Mathematical modeling is a non-linear process of mathematical thinking, which includes a cyclic movement from the real world to the world of mathematics and back. The first step of mathematical modelling is to understand real life situations trough parameters that define them, and a selection of parameters, which enable a simplification of a problem. The second step is a mathematisation of a problem by developing a mathematical model. In the third step we predict a development of a real situation with the help of a constructed model. In the fourth step we verify, confirm and report results (Lesh and Doerr, 2003).

In the context of primary school, we interpret a model, in the theory of complex systems language, as a "system of elements, relations and rules that are used to describe or to anticipate behaviour of other similar systems" (Doerr and English, 2003, p. 112). We first present a problem which promotes the need to develop a model to describe, explain and predict behaviour of a given system (model-eliciting problem). Re-use and a generalisation of models are two central activities in modelling on a primary level, which is why students in the next step solve models for research (model-exploration problem) and models for use (model-application problem) to enable expansion, exploration and improvement of constructs/models, which were developed in the initial phase (Lesh, Cramer, Post, Doerr and Zawojewski, 2003).

Final reports contain various parameters, relations and operations, which offer an effective means of insight into students thinking while modelling and what they perceive as important. In contrast to typical situations in a math classroom, modelling provides great social experience, which is in accordance with the currently accepted paradigm of social constructivism. Because students work in smaller groups, they become motivated for an exchange of views, which encourages explanation and reasoning. While students develop, test and prepare reports, they form questions, interpretations, revisions, conclusions and conflicts. Collaborative learning is therefore an optimal design for work with modelling, which is not practised very often in mathematics classes in Slovenia or other countries (Zawojewski, Lesh, and English, 2003).

Modeling as an approach to teaching is closely related to the process of progressive mathematisation, as described by Freudenthal (1991, after Heuvel - Panhuizen, 1996), which was created in the framework of a realistic approach to teaching mathematics in the Netherlands. The main principle of realistic mathematics is a development of a formal knowledge based on children's informal strategies, because children often face various mathematical problems before entering school. Teaching mathematics in school should not be separated from the real world, but associated in a way, that students can use their previously acquired knowledge and experience. Basic method of realistic mathematics is therefore a link of mathematical concepts with real situations, which are known to students and taken from everyday life. Math, linked to the context, serves formal mathematics, where models are intermediaries. Models should definitely respond to particular specifications in order to execute a bridging function between informal and formal mathematics. In addition, they must have a strong role in the first stage of informal and last stage of formal standardized mathematics, as well as in intermediate stages. Models must bind naturally or be taught to students' methods. Schematisation and summarisation of models, which lead to pure mathematics and its generalisation in use, must be gradual and natural. Children, who construct and work with modules, show a real educational path to a formal level under an appropriate leadership of a teacher and a group. As an upgrade to a realistic approach, steps of mathematical modelling present a cyclical process (Repolusk, 2010):

- Understanding and identifying the problem.
- Designing parameters and a mathematical formulation:
    a. Identifying and classifying variables.
    b. Identifying connections between variables and auxiliary models.
- Solving the model.
- Verifying the model:
    a. Is the model related to the problem?
    b. Does this model make sense?
    c. Testing the model with real data.
- Use (implementation) of a model.
- Model improvements.

In primary school cyclicality is somewhat simplified (Magajna, 2012), because students' knowledge is still limited:

- Interpretation of situations.
- What else could be taken into account?
- What will be taken into account (parameters)?
- Translation into a mathematical form, calculation.
- Interpretation of a solution.
- Addressing the adequacy of a solution.

– Reporting.

Cyclicality is included in the assessment of adequacy of solutions and relevancy of parameters. The constructed model serves as a substitute for thinking and contains a structural similarity to representations in different contexts. Models are mutually interchangeable, cognitively available to students, autonomous and limited (Magajna, 2012).

In primary school, we must be aware of the limitations in using modelling as a method of problem solving due to different stages of student development (from primary to secondary school). Emphases on modelling in primary school (Magajna, 2013):

– Interpretation platform of an exercise.
– Formulation of constraints. Justification of a chosen interpretation, restrictions and set hypotheses.
– There is not much emphasis on calculation or selection of a mathematical model, due to a limited mathematical knowledge of students.
– Interpretation and validity of calculations.
– Coordination of actors on interpretations, constraints and set goals.
– Record of a modelling process, presentation of a model.

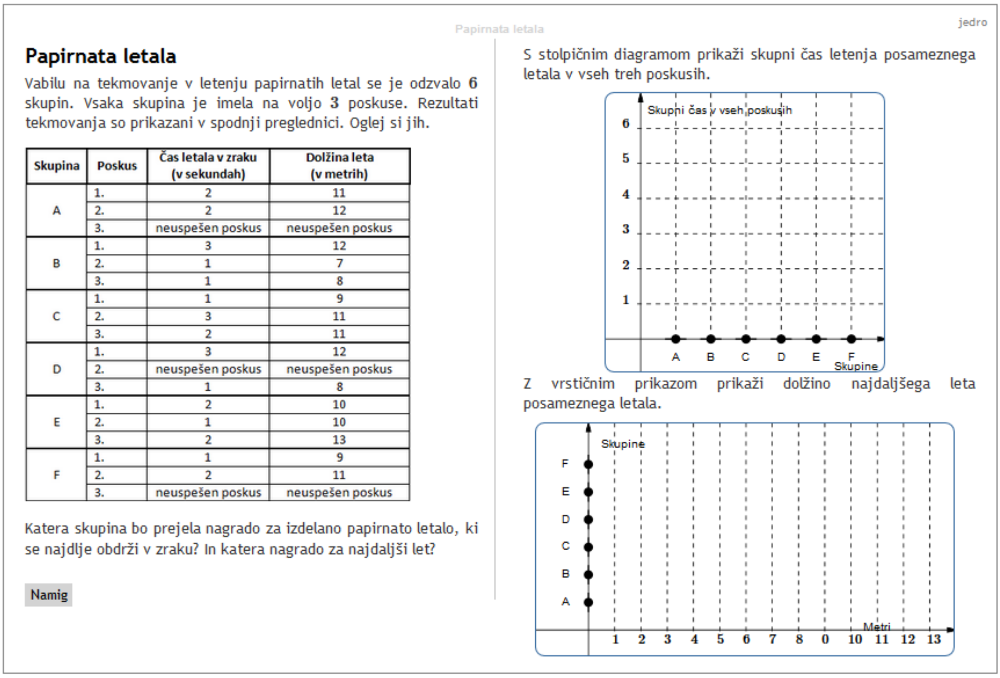
In the following section we present the use of i-textbooks and the use of modelling as one of the options for solving problems in real context, taking into account the fact that, construction of a model is essential in modelling and that we should not limit ourselves to a realistic reflection (Magajna, 2013). Normal exercises with a realistic reflection, such as e.g., How many 25 seater buses do we need to transport 134 students?, therefore, do not satisfy the base condition an exercise used in modelling approach.

Modelling in i-textbook on a class level in primary school

Modelling on a class level requires the following type of knowledge (Magajna 2012, after English2004): interpretation of information from the text, reading simple displays, reading information from simple tables, collecting, analysis, presentation of data, preparation of a report on a solution, group work and presentation of exercises and process of solving or results.

In the I-textbook for mathematics in 5th grade we can find a unit "Presikave, modeliranje" (Investigation, modelling) (http://eucbeniki.sio.si/admin/documents/

learning_unit/752/Preiskava_L_JSX_1381219697/index6.html). The introductory exercise is created on an example by English and Waters (2004) and is an example of problem that elicits a model. The exercise is made on topic of a paper airplane competition and is presented through a realistic invitation to teams, who are applying for the competition, in a form of a leaflet. Students must, as a part of commission for granting awards, draw up criteria for the awards. In the competition each team is involved in three flight experiments, where length of a flight and flight time is measured. Unit leads students to tabulate criteria for achieving point in both parameters. Since this is their first encounter of modelling, the data is simple. Mathematical model is simple - tabulating and summation.


Papirnata letala

jedro

Papirnata letala

Vabilu na tekmovanje v letenju papirnatih letal se je odzvalo **6** skupin. Vsaka skupina je imela na voljo **3** poskuse. Rezultati tekmovanja so prikazani v spodnji preglednici. Oglej si jih.

Skupina	Poskus	Čas letala v zraku (v sekundah)	Dolžina leta (v metrih)
A	1.	2	11
	2.	2	12
	3.	neuspešen poskus	neuspešen poskus
B	1.	3	12
	2.	1	7
	3.	1	8
C	1.	1	9
	2.	3	11
	3.	2	11
D	1.	3	12
	2.	neuspešen poskus	neuspešen poskus
	3.	1	8
E	1.	2	10
	2.	1	10
	3.	2	13
F	1.	1	9
	2.	2	11
	3.	neuspešen poskus	neuspešen poskus

Katera skupina bo prejela nagrado za izdelano papirnato letalo, ki se najdlje obdrži v zraku? In katera nagrado za najdaljši let?

Namig

S stolpičnim diagramom prikaži skupni čas letenja posameznega letala v vseh treh poskusih.

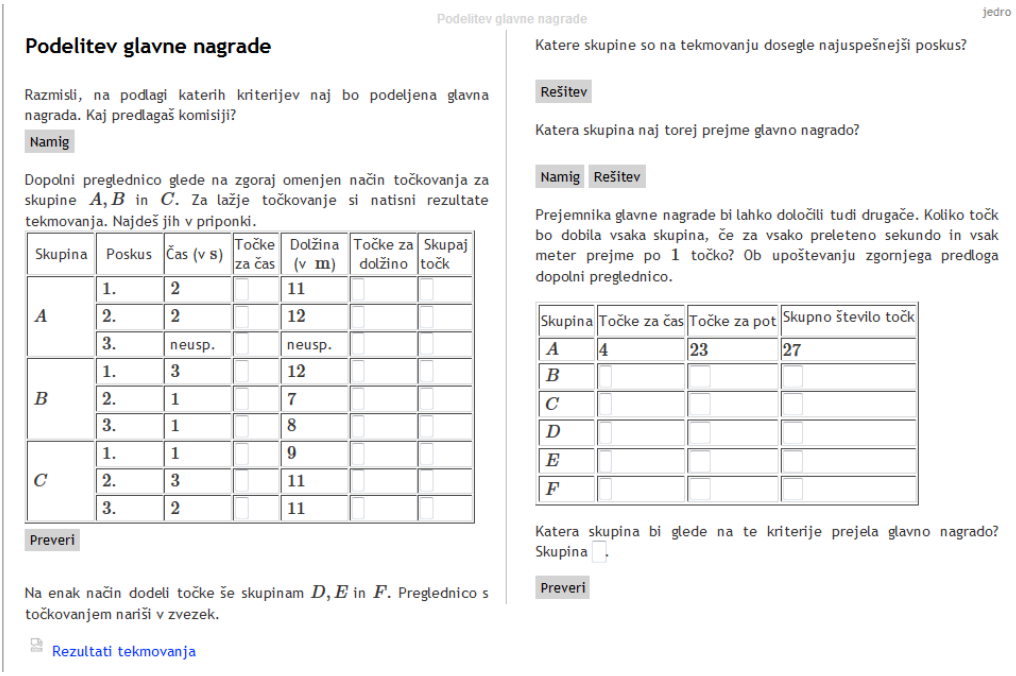
Z vrstičnim prikazom prikaži dolžino najdaljšega leta posameznega letala.

Figure 1: Paper airplanes - interpretation (Source: http://eucbeniki.sio.si/test/iucbeniki/mat5/752/index1.html)

Two possible scoring models are presented in which data is selected in a way that determining the criteria for the main prize is not an option (the total number of points by individual parameters is proportional). The comparison of scores for longest flight and longest air time determines the main prize in both models.

In the next example students meet a somewhat more demanding problem. Mr. Jože is planting beans on a sunny and a full shadow bed. The exercise has already been tested (English and Waters, 2004) as an example of problem that elicits modelling. The data on crops is already given in a table; students' job is to advise Mr.

Jože where he should plant more beans in the following year. Since the data is realistic, they must take into account the fact that beans grow faster on a sunny bed, but shade is needed at the time of harvest. The expected mathematical model is a vertical bar chart and the interpretation of results requires reflection on various parameters, which affect the crop. A possible solution to this problem is provided in order to direct students to a reflection of parameters that they might not have thought of (e.g., soil quality).



Podelitev glavne nagrade

jedro

Podelitev glavne nagrade

Razmisli, na podlagi katerih kriterijev naj bo podeljena glavna nagrada. Kaj predlagaš komisiji?

Namig

Dopolni preglednico glede na zgoraj omenjen način točkovanja za skupine A, B in C. Za lažje točkovanje si natisni rezultate tekmovanja. Najdeš jih v priponki.

Skupina	Poskus	Čas (v s)	Točke za čas	Dolžina (v m)	Točke za dolžino	Skupaj točk
A	1.	2		11		
	2.	2		12		
	3.	neusp.		neusp.		
B	1.	3		12		
	2.	1		7		
	3.	1		8		
C	1.	1		9		
	2.	3		11		
	3.	2		11		

Preveri

Na enak način dodeli točke še skupinam D, E in F. Preglednico s točkovanjem nariši v zvezek.

Rezultati tekmovanja

Katere skupine so na tekmovanju dosegle najuspešnejši poskus?

Rešitev

Katera skupina naj torej prejme glavno nagrado?

Namig Rešitev

Prejemnika glavne nagrade bi lahko določili tudi drugače. Koliko točk bo dobila vsaka skupina, če za vsako preleteno sekundo in vsak meter prejme po 1 točko? Ob upoštevanju zgornjega predloga dopolni preglednico.

Skupina	Točke za čas	Točke za pot	Skupno število točk
A	4	23	27
B			
C			
D			
E			
F			

Katera skupina bi glede na te kriterije prejela glavno nagrado? Skupina .

Preveri

Figure 2: Paper airplanes - scoring (Source: http://eucbeniki.sio.si/test/iucbeniki/mat5/752/index2.html)

Third problem puts a student in a role of a planner for a trip to Toronto. A table includes all data on nine airlines, number of stops, flight time (originating and return flight time) and a return ticket price. This time students cope with five parameters to plan a flight so that an airline ticket is as cheap as possible, has fewer stops and shortest flight time. A hint suggests organizing parameters and assignment and setting an appropriate number of points. Total amount of points determines the right choice.

Fifth task, which belongs to the model-exploration problem, is about a competition in summer reading and has also been tested (English and Fox, 2005). A commission will take following parameters into account in determining a winner: the number of books read, difficulty of books read (depending on students' grade), the volume of books read and the quality of a book summary. All data is already provided i.e. volume of books, description of books, evaluated summary, and examples of letters to the commission with proposals for a scoring system to determine the winner. This exercise is quite complex, since the parameters and data is selected in a way that requires a selection of specific restrictions (which parameters are taken into account) and in accordance with this a construction of an interpretation. Parameters are also linked to each other (e.g. difficulty of a book depends on the age of a reader), which must be taken into consideration in the construction or an improvement of a model. Students must make a fully informed selection of one proposal in the letters and then prepare their own proposal.

The acquired knowledge is then applied in two more problem examples that use a model in real life situations. In the first case, they must choose a hotel with information given on price per person, air conditioning, wireless internet access and a distance to the beach and centre of the city; in the second case they must decide on a Sunday mountain hike, where given parameters include peak height and number of routes that lead to the top.

It is evident that this new approach requires all tasks to center on an interpretation of the text read, setting limits (parameters) and interpretation of results. Mathematical models are very simple (tabulating and summation) and focused on a critical reflection of content read. These exercises require a report, which is why we propose team work guided by a teacher through different models of cooperative learning.

Modelling in i-textbook on a subject level in primary school

Let's look at an example of a model development in 8th grade. This example is found in the i-textbook for 8th grade (http://eucbeniki.sio.si/test/iucbeniki/mat8/824/index3.html). Students first interpret the situation shown in Figure 3, with which they focus on polygons, describe it with their own words or a sketch (Magajna, 2013). The exercise is set in a real context, where we need to know the size of the terrace, choose the type of pavements and calculate how much pavement we need. Deciding parameters are quality, price, etc.

The exercise is as follows:

Family Novak wants to pave their terrace. Using the data below calculate the cost of pavement and select the most favourable option.

When we interpret the situation (students can help themselves with Hints) and think about what else can be taken into account, we decide on the parameters we will use. We decide which stone to use and the cost of pavement. Two options are available for the pavements (a square and a rectangle that is not a square). In the next step we calculate the price of pavement with each type of stone. This model is, of course, useful regardless of the selected type of stone. We then calculate the surface of the terrace, calculate the minimum amount of pavement required for the whole terrace and the cost for the purchase of the necessary quantity of stone. In the i-textbook author adds an option to consider some additional costs (preparation of the terrace, curbs, sand, work, etc.), but they are not included in the calculation, since we can predict similar costs irrespective of the chosen type of stone. In a real life situation we would probably take this into account. This is the phase of a solution interpretation. We then consider if the selected situation corresponds to our model (calculation procedure, with which we calculate the cost of paving stones). We transformed a geometric concept into an arithmetic (algebraic) concept (Magajna, 2012). Selecting a different type of stone does not change the model. Then we check the validity of the model on other real life scenarios (assessment of solution adequacy). If we discovered, by changing the type of stone, that our model had no validity in a real situation, we would have to change the model. Activity in the i-textbook enables independent resolving of problem tasks in real context by modelling.

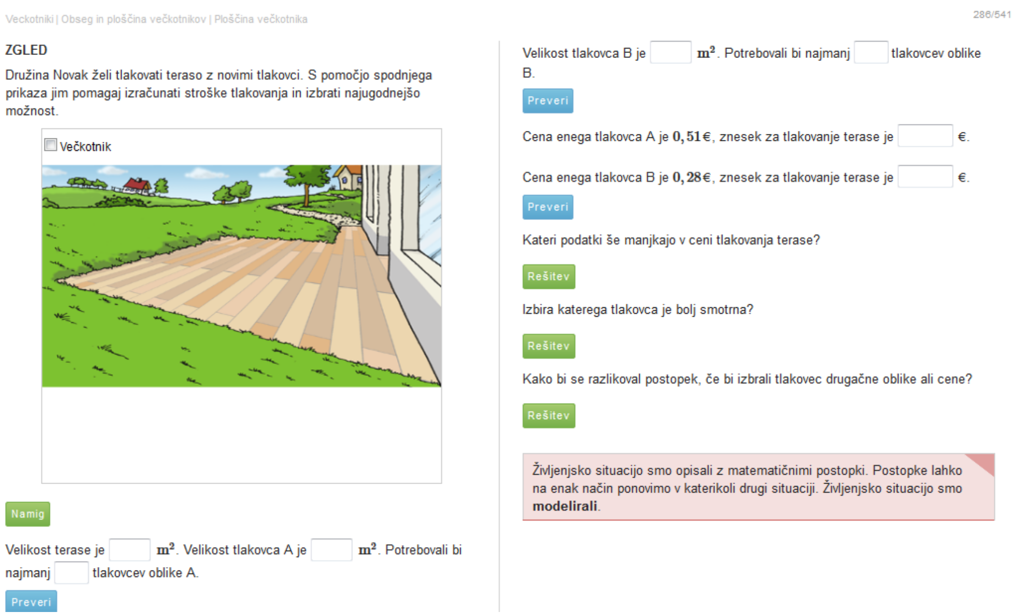


Figure 3: Paving (Source: http://eucbeniki.sio.si/test/iucbeniki/mat8/824/index3.html)

With the concept of model development, students consolidate their understanding with more exercises.

Exercise 12 on page 291:

Construct a computational model, with the help of which you will be able to calculate the cost of laying wall tiles in the bathroom. Compare your model to models of your classmates.

This exercise does not provide a unique solution. Students are encouraged to produce a calculation model, which calculates the cost of laying tiles in the bathroom. The exercise can encourage students to talk to their parents about requirements for laying tiles. Students can therefore choose various starting points and consider various parameters. This will not make models vary substantially; it all depends on the selected parameters. When choosing parameters, students should take the following factors into account (Magajna, 2012):

– Are parameters reasonable, sensible, too narrow, adequate, etc.?
– How to justify each selected parameter?
– What information is needed for the use of the model?
– Can we justify parameters by observation, measurement?
– How do we test adequacy of the model?

We examined an example of a computational model.

In ninth grade, in the section on linear functions, we find the following exercise:

Miha has a choice of two window cleaning companies. Company "Always clean windows" charges 5 € per window and company "Never dirty windows" charges 20 € for the service and 3 € per window. With the help of computer technology research, which company is less expensive. Justify your answer based on the number of windows.

At first glance, this does not call for standard modelling, since we are looking for an answer to a specific question with a known starting point (two cleaning companies and choosing the inexpensive one). The exercise instructions lead the student to use computer technology and to use a bar graph to display the expenses for a certain number of windows. With the display of expenses in a coordinate system we construct a model, which tells us which provider to hire for a certain amount of windows. Designed model helps students with similar problems in real life context. This problem-situation was presented with a model of linear functions and knowledge of properties of a linear function.

An even more effective display in a real life situation is a model we can find in a set of exercises for the eighth grade: http://eucbeniki.sio.si/test/iucbeniki/mat8/837/index6.html, 12th exercise reads:

Plant beans into two pots. Place one pot in the light. Place second pot in the dark. Water both pots evenly. Follow the growth of both beans. Monitor daily growth and record the results in a table.

a. *Present bean growth with an appropriate display.*

b. *With the help of data examine the effect of light on growth.*

c. *Based on data, can we deduct the form of growth curve for all types of beans?*

Students directly affect the observation and a final model by selecting parameters (type of bean, soil, ambient temperature, light, humidity, air quality, etc.). With a controlled experiment of bean growth in the dark, they actually confirm effects of light on the growth of beans. Display bean growth has a typical shape. If students choose different varieties of beans or even corn (or anything else) and compare graphs, they can clearly confirm the hypothesis that all plants grow similarly. This is how they construct a model of growth.

Conclusion

Mathematical modelling can be defined as a "natural sciences research" in the field of mathematics. A scientific method is obviously convenient for teachers of science subjects, but it is more difficult to implement in a mathematical classroom. Students, who are engaged in activities of mathematical modelling, spend most of the time thinking about realistic situations with the aim of finding patterns and rules. A part of the incentive for mathematical modelling lies in the fact that this kind of activity will help students understand that math is not a discipline, in which we come up with solutions in a few minutes. Each good mathematical modelling is at least partly unclear. Modelling is a complex activity, where numerous competencies of a student come to the fore (Magajna, 2013). Development of students' competencies is one of the key tasks required by the curriculum.

In this article we presented a concrete implementation of modelling, on a class and on a subject level.

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How to proceed

Development of a modern e-environment and i-textbooks for Social Sciences in the frame of "E-šolska torba" ("E-school bag") project.

Andrej Flogie, Vladimir Milekšič, Andreja Čuk, Sonja Jelen

This article presents a summary of current activities in the field of modern e-content development. It provides an overview of current e-learning materials development, as well as the development of interactive textbooks for science. All findings acquired in the previous projects in the area of e-content development will be revised in accordance with the vision and results of the work which will be carried out in this field within "e-school bag" project (the development and the use of e-content). The key emphasis is in the area of the vision itself, as well as in the integrated approach to the development and use of advanced e-content and its evaluation in practice.

Key words: e-school bag, i-textbooks, educational platform, 1:1 pedagogy, education

Introduction

All of the international research, in particular the research on literacy, which we also performed in Slovenia (PISA, PIRLS), indicate, that the biggest part of student achievements depends on factors found at home, especially educational attainment of parents and the amount of books at home. Both of these factors have a direct and an indirect affect; educational attainment of parents has an indirect effect on the life-style and provides an opportunity for a child to receive a sufficient amount of reading stimuli, as parents and school will probably expect high academic achievements, which a child will most likely meet (this is not the case for each individual). The percentage of difference in literacy provided by the school is, according to the most recent data by PIRLS in 2011, only 8 %. This does not mean that the school is not able to do anything about it, on the contrary, the school does so little, that the effect of domestic environment is (too) great. If we compare reading literacy of children in families with differently educated parents, we can see that there is a 100 points difference in reading literacy among a group of children, who have university educated parents, and children whose parents only completed primary school, and we know that a difference of 40 points means a difference of a year (1 year older and one grade higher students would achieve this amount of reading literacy), which means, that at the age when differences begin to vary steeply, various groups of children have a difference of two and a half years.

In this context a question arises, whether modern information technology may have an effect on schools, which would help increase achievements of students, as well as development of literacy as one of the fundamental conditions for successful learning. Information technology may have a direct or an indirect impact on literacy; directly with an exposure to reading stimuli, especially if the computer is connected to the Internet and indirectly with exposure to a large quantity of information, which can be processed with knowledge of information technology use. This process is circular: the more we read, the better we read and the better we read, the more we like it. Anyone who reads more (if difficulty increases over time) reads better (Doupona, 2012).

On the basis of these fundamental reasons, general and specific competences of the 21st century, required innovative approaches to teaching and learning supported by advanced e-services, quality e-content and future technologies (mobile devices, tablets, etc.), we want, in the framework of the "E-school bag" project, to develop mechanisms, examples of good practices and modern e-services and e-content (i-textbooks), which will be a foundation for further infrastructure and systemic measures in the Slovenian educational environment.

The "E-school bag" project is a development project with the aim of i-textbook evaluation at selected public educational institutions. In order to successfully carry out pilot projects we will establish appropriate infrastructure, develop e-services and e-content (i-textbooks). Developed e-services and e-content will be, after successfully completed pilot projects, accessible to all schools (and not just those involved in pilot projects).

The purpose and objectives of the project

The purpose of this project is to establish an appropriate infrastructure for the use and development of modern e-services and e-content in Slovenian language, providing support for application of these materials (didactic, technical) and organizational/management process of each educational institution in increasing the level of e-competences and knowledge of our teachers/professors, and indirectly an improvement of competitiveness of knowledge of our students in the European Union. Developed e-services and e-content will be supported by consultants and experts and tested in practice in the educational institutions' pilot network. In the future, an application of developed e-services and e-content will also be made available to other educational institutions in the Slovenian educational environment.

The objectives and associated priority areas of this project are:

– development of modern e-services for the Slovenian educational environment,

– development of e-content (i-textbooks) for social sciences (8th, 9th grade of primary school and 1st year of gymnasium),

– ensuring accessibility and support of newly developed e-services and e-content,

– development of a single authorial user interface for "online" preparation of e-content,

– development of a single platform for access to e-content - "EduStore" (i-textbooks, e-books, etc.),

– development of e-services for the use of developed e-content with different clients,

– establishment and development of infrastructure (transition to Internet Protocol version 6 (IPv6), the Slovene educational network II (SIO II) and pilot projects),

– implementation of pilot projects of "E-school bag" use (which will cover both pedagogic-educational and organizational-management part of every educational institution).

– evaluation of effects.

The project contributes to a better quality and efficiency of the educational process for social sciences subjects in 8th and 9th grade of primary school and 1st year of gymnasium by creating conditions for the use of ICT in school work (teaching and management) through teacher training (both in school and individual work at home), implementing project results into the educational process and development of digital competencies of teachers and students.

The pilot project "E-school bag" is an upgrade and a continuation of some already established activities in the field of computerisation of education. Public institution Arnes has established a foundation for SIO - Slovenian educational network (developed certain e-services, established a necessary part of ICT infrastructure) and the public institution ZRSŠ has already started with the construction of modern e-content (i-textbooks) in the field of natural sciences (12 are already confirmed, others are in the process of certification by the Council of Experts for General Education). Good practice, knowledge and experience gained from these projects will be transferred to the "E-school bag" project, upgraded and expanded. Arnes already established some basic e-services (e.g. Vox - videoconferencing systems, voting system, etc.), e-content for natural science areas is being developed and a network of consultants for the use of e-services and e-content has already been developed for Slovenia, etc. A tool for development of modern e-content already exists, but it is still available on a "desktop" level with limited use and not online as a web application. Knowledge, approaches and experience gained at this level will serve as a basis for building web platforms to develop e-content. For development of other platforms and interfaces, however, a HTML5 standard will form a basis for future work, so that all e-services will be developed in accordance with the recommendations of this standard (in the framework of the EU interoperability environment).

Pilot projects on modern e-services and e-content use on tablets in educational institutions will be based on the experience and help of consultants from The National Education Institute of The Republic of Slovenia, experts from Arnes, Innovative schools programme titled "Partners in Learning", which runs in more than 65 countries around the world (http://www.pil-network.com/pd/school), project "Inovativna pedagogika v luči kompetenc 21. stoletja" (Innovative pedagogy in the light of 21st century competences) and on the basis of the "e-kompetentni učitelj" (e-competent teacher), which was developed in the framework of the "E-šolstvo" (E-educational system) project.

The role of i-textbooks in the "E-school bag" project

Development of i-textbooks (Pesek, Zmazek and Mohorčič, 2014) in the Slovenian education environment is based on the findings and conclusions of e-materials development, production of which is financed through a public call for tenders by the Ministry of Education, Culture and Sport. The next step was developing a concept, methodology, and in the last phase, prototype i-textbooks in the field of natural sciences, which were held under the auspices of The National Education Institute of The Republic of Slovenia, and a project financially supported by MIZS titled "Razvoj i-učbenikov za naravoslovje" (Development of i-textbooks for science) under the leadership of dr. Igor Pesek. All the methodology of developing i-textbooks, including their didactic and educational role in the education process was developed in the framework of this project. Many innovative teachers from all over Slovenia (both primary school and secondary school teachers) as well as other experts in specific fields were involved in this project. From a technological point of view, we developed an editorial web portal and an upgraded/modified editor for development of i-textbooks (eXeCute). The e-school project represents the next logical step in development of i-textbooks. All already developed methodology, knowledge, steps, etc., are used and upgraded in areas where they are required.

An upgrade is especially needed in the area of technology, licensing model and use in a classroom, while the didactic-methodological concepts and approaches of already developed i-textbooks in the field of natural sciences are also relevant for development of i-textbooks in the field of social sciences. Within the "E-school bag" project, in the field of development of i-textbooks, we adopted all substantive work methodology in development of each textbook.

Platform Development

Online e-content editor

A general assessment of the existing i-textbook editor (eXeCute), which has been developed and refined in the framework of the "Razvoj naravoslovnih i-učbenikov" (Development of science i-textbooks) project, is very high. The key issue is, of course, that this application functions only locally and is limited to a local computer’s operating system. This means that it has to be installed on a local computer with a suitable operating system Windows and is not compatible with other operating systems. It also does not provide team work or direct storage in a cloud. However, it is much more advanced than most of the other existing applications/tools for development of e-content, as its functionality is actually tailored to the needs of modern e-content as well as i-textbooks. This is why we decided, already in planning of the "E-school bag" project, to develop an identical application (e-service), which will include all the functionality of the eXeCute tool and will be upgraded in the sense of:

- working online (local installation is not required)
- runs in Arnes' cloud
- provides online data storage (Arnes' cloud, etc.)
- provides a free online registration for each publisher (a teacher can also be a publisher) and assigning corresponding rights to manufacturers of content (every textbook may have one or more authors)
- provides direct communication via APP with EduStore (a developed i-textbook can be directly exported to EduStore)
- provides joint editing of documents (multiple authors can edit the same textbook - each a specific part)
- provides direct communication with an existing administrative web portal (reviewer, editorial policy, etc.)
- provides different types of export of developed i-textbooks (export directly to EduStore, ePub, html5, SCORM packages, etc.)
- all records are compatible with an attached XML scheme
- enables different CSS-styles (prepared form of content)
- etc.

An installation of the online e-content (i-textbooks) editor in an integrated platform is shown in the following diagram.

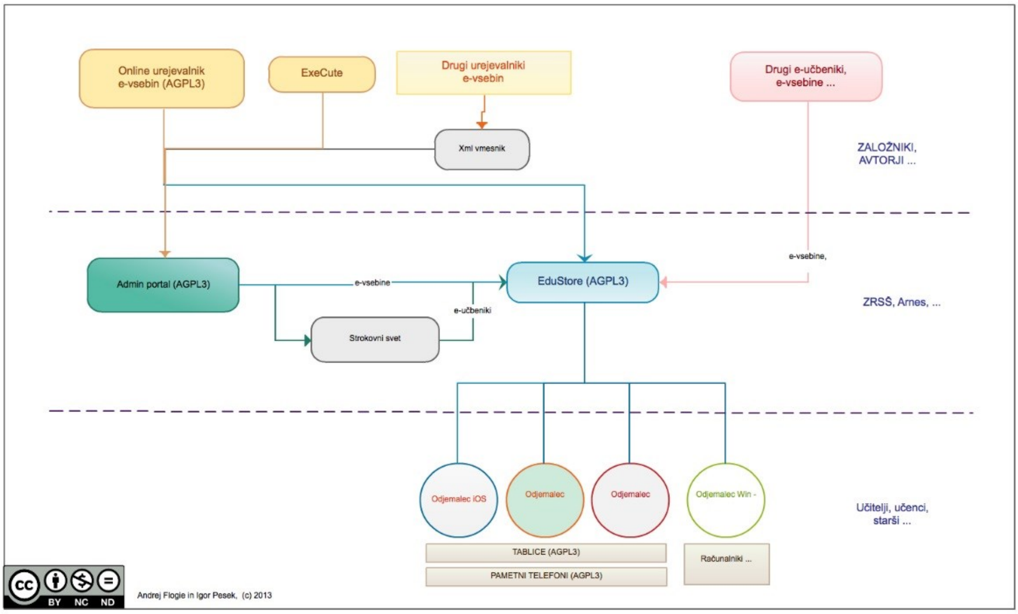


Figure 1: Ecosystem - platform for the use of i-textbooks

XML-interface (a conversion system for i-textbooks from XML to HTML5 format)

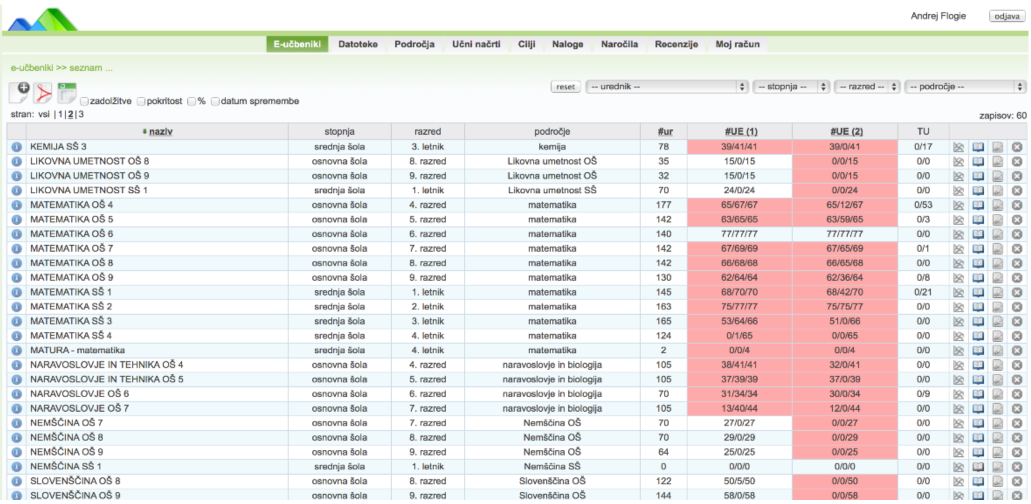
The overall vision of the platform is to enable free access and open source features and functions. From a substantive view of e-content development, this means that we do not want a closed and restricted environment. We want authors to also use other tools for development, publish their final product in the EduStore and thus apply another already developed and established infrastructure for distribution. In the long-term, this means that a publishing house can also use the established infrastructure as a distribution channel for use of their i-textbooks and e-content on a tablet, smart phone, online, etc. This is why we developed an XML-interface system for conversion of e-content from XML to HTML5. The basic purpose of the XML-interface is to enable conversion of i-textbooks into a uniform format regardless of the type of software used in its development. We want to enable a conversion from a standardized XML to a HTML format and maintain the flexibility of using templates and CSS-styles to define the final form of an i-textbook, which will be uniform regardless of the type of software used in its development.

Authors and publishers have a choice to use the free access online e-content editor or any other commercially available product. In any case, they have a possibility to use any other established infrastructure, which is of key importance to us (i.e. an open environment and a wide range of creative and innovative approaches to development of e-content).

Administrative web portal

The administrative web portal functions as a tool for organising the entire process of i-textbook development. The portal enables formation of a concept layout of an i-textbook, assignment of content sets to authors, supporting authors in creating individual units, unit reviews (simultaneous reviews), proofreading, final technical processing and development of an i-textbook.

The portal was fully developed in the framework of the project of developing textbooks for natural sciences. In the framework of the "E-school bag" project, the portal will be upgraded in certain segments, which have become just as important due to an integrated approach. It will be upgraded in the field associated with the online e-content editor, because it is necessary to ensure connectivity via APP or via appropriate technological solutions. Reviewing cycles will also have to be upgraded, since they will be implemented in different ways, depending on the approach of an individual or a single publishing house to development of e-content. All of these adjustments and upgrades will contribute to the corporate platform image. Administrative management of the portal will continue to remain in the domain of The National Education Institute of The Republic of Slovenia, which is also closely involved in the process of validation of textbooks and professional assessment of their suitability.


Andrej Flogie odjava
E-učbeniki Datoteke Področja Učni načrti Cilji Naloge Naročila Recenzije Moj račun
e-učbeniki >> seznam ...
reset -- urednik -- -- stopnja -- -- razred -- -- področje --
zadolžitve pokritost % datum spremembe
stran: vsi | 1 | 2 | 3
zapisov: 60

naziv	stopnja	razred	področje	#ur	#UE (1)	#UE (2)	TU
KEMIJA SŠ 3	srednja šola	3. letnik	kemija	78	39/41/41	39/0/41	0/17
LIKOVNA UMETNOST OŠ 8	osnovna šola	8. razred	Likovna umetnost OŠ	35	15/0/15	0/0/15	0/0
LIKOVNA UMETNOST OŠ 9	osnovna šola	9. razred	Likovna umetnost OŠ	32	15/0/15	0/0/15	0/0
LIKOVNA UMETNOST SŠ 1	srednja šola	1. letnik	Likovna umetnost SŠ	70	24/0/24	0/0/24	0/0
MATEMATIKA OŠ 4	osnovna šola	4. razred	matematika	177	65/67/67	65/12/67	0/53
MATEMATIKA OŠ 5	osnovna šola	5. razred	matematika	142	63/65/65	63/59/65	0/3
MATEMATIKA OŠ 6	osnovna šola	6. razred	matematika	140	77/77/77	77/77/77	0/0
MATEMATIKA OŠ 7	osnovna šola	7. razred	matematika	142	67/69/69	67/65/69	0/1
MATEMATIKA OŠ 8	osnovna šola	8. razred	matematika	142	66/68/68	66/65/68	0/0
MATEMATIKA OŠ 9	osnovna šola	9. razred	matematika	130	62/64/64	62/36/64	0/8
MATEMATIKA SŠ 1	srednja šola	1. letnik	matematika	145	68/70/70	68/42/70	0/21
MATEMATIKA SŠ 2	srednja šola	2. letnik	matematika	163	75/77/77	75/75/77	0/0
MATEMATIKA SŠ 3	srednja šola	3. letnik	matematika	165	53/64/66	51/0/66	0/0
MATEMATIKA SŠ 4	srednja šola	4. letnik	matematika	124	0/1/65	0/0/65	0/0
MATURA - matematika	srednja šola	4. letnik	matematika	2	0/0/4	0/0/4	0/0
NARAVOSLOVJE IN TEHNIKA OŠ 4	osnovna šola	4. razred	naravoslovje in biologija	105	38/41/41	32/0/41	0/0
NARAVOSLOVJE IN TEHNIKA OŠ 5	osnovna šola	5. razred	naravoslovje in biologija	105	37/39/39	37/0/39	0/0
NARAVOSLOVJE OŠ 6	osnovna šola	6. razred	naravoslovje in biologija	70	31/34/34	30/0/34	0/9
NARAVOSLOVJE OŠ 7	osnovna šola	7. razred	naravoslovje in biologija	105	13/40/44	12/0/44	0/0
NEMŠČINA OŠ 7	osnovna šola	7. razred	Nemščina OŠ	70	27/0/27	0/0/27	0/0
NEMŠČINA OŠ 8	osnovna šola	8. razred	Nemščina OŠ	70	29/0/29	0/0/29	0/0
NEMŠČINA OŠ 9	osnovna šola	9. razred	Nemščina OŠ	64	25/0/25	0/0/25	0/0
NEMŠČINA SŠ 1	srednja šola	1. letnik	Nemščina SŠ	0	0/0/0	0/0/0	0/0
SLOVENŠČINA OŠ 8	osnovna šola	8. razred	Slovenščina OŠ	122	50/5/50	0/0/50	0/0
SLOVENŠČINA OŠ 9	osnovna šola	9. razred	Slovenščina OŠ	144	58/0/58	0/0/58	0/0

Figure 2: Screenshot of an Administrative web portal

EduStore

When development of content is complete, it is simply exported to the EduStore. It is a uniform e-content storage for a large part of the Slovenian educational environment. We can say that it is, from a logical and technological point of view, an upgrade to the current catalogue of e-materials Trubar (which is located on the portal SIO). The Trubar catalogue has 8500 active e-materials. These are stored in a form of external links, SCORM files, pdf and ppt files, etc. The whole system is composed of two components: the Alfresco document system, in which all e-materials are stored, and a Typo3 user interface, which allows users to search and browse e-materials. Because of a specific record of documents in the Alfresco system, classification was made using a tree structure (level → class → subject). For easier search and subsequent integration with the e-materials database, we introduced a fourth level: thematic sets. All the elements of classification operate on a user interface level as search engine filters. Because it turned out that a tree structure is not the most suitable record structure in the long-term (e.g., it is impossible to find all materials for physics at all levels of education), we decided to use independent metadata. In doing so, we will improve the quality of the search engine as well as its speed.

Materials that have been submitted in the catalogue as SCORM files are currently displayed in a dedicated online Moodle classroom, which can be substituted with a special SCORM viewer. A user will be able to preview specific e-material and upload it to an online classroom. Another problem is external links that, due to the nature of the Internet, do not always provide a valid link. A long-term goal that we have set for ourselves a long time ago was that all materials would be stored locally in a catalogue. A catalogue and collections of material are a good basis for new generations of e-materials, i-books and other e-content.

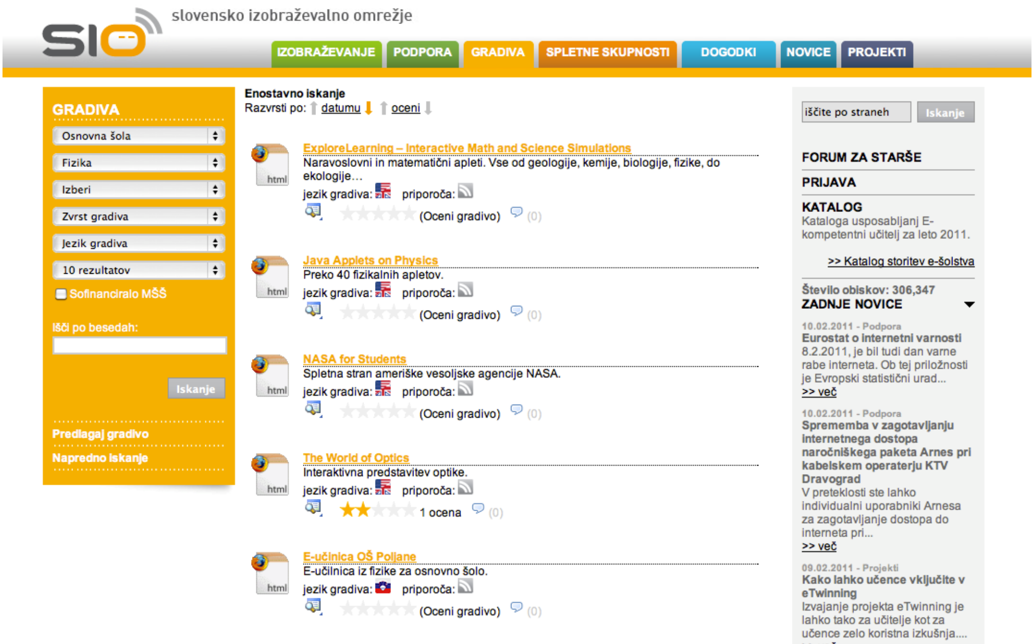


Figure 3: The current catalogue of e-materials on SIO portal

EduStore presents a logical upgrade to the existing Trubar catalogue both from a substantive and from a technical point of view. EduStore is composed of two components i.e. web applications:

– administration part

– user part

The administration part is intended for publishers and system administrators as a tool for various functionalities such as summary statistics, content management, publishing of content, user administration, etc. The user part provides another set of functionalities, such as access to e-content, purchase of e-content, editing and reading e-content, etc. The user part also serves as an API through which mobile device users communicate with the EduStore system.

Both parts of the application are separated and access data trough a single uniform database, but each part has its own access rights. Users can access the administration part of the application only via a PKI infrastructure, while the user part of the applications has multiple authentication methods. Both parts of the application use SSL.

Clients

Prepared content (i-textbooks, e-content, etc.) will be stored in EduStore. Due to various providers of mobile phone hardware and software, tablet computers, etc., a problem occurs on how to ensure access to the same content with different devices with different operating systems. Our vision is, of course, that authors prepare their content only once. The technology then provides a function to generate content in appropriate technological formats, which will allow access regardless of device type used. This is why we developed an application which enables access for three different operating systems: Windows, Android and IOS.

This mobile application will provide users with an access to e-content from various devices, but the user will have to download the "E-torba" ("E-school bag") application from official stores (AppStore, Google Play, Windows Store). Development of native applications for each operating system is needed to ensure a good user experience, which also demands a tailored look/appearance/external image and functionality of the mobile application. We have contracted a design of information architecture, which will provide an intuitive use of the application and a unique graphical interface, which will follow trends of other mobile applications and best user experience.

The purpose of this mobile applications is for the users (students, teachers, parents, etc.) to use the "E-bag" application to download i-textbooks to their device and use them in all forms (browsing, interactive solving of exercises, etc.). The exercise solutions will, if the user chooses to, be saved within the application or in his/her device.

The introduction page of the application shows i-textbooks and other e-content that has already been transferred to the device. We also want to offer other i-textbooks (e-contents) according to user preferences, past searches and already downloaded content and suggest new ones (if there are any and if the administrator added them to the EduStore). All suggestions are presented with a preview image of the i-textbook (e-content), title and a brief description of the content. A button for simple and quick transfer of content is also available.

Figure 4: Application download - Google play

Testing i-school textbooks and first findings

In the framework of the "E-school bag" project we are developing i-textbooks for social sciences subjects for the 8th and 9th grade of primary school and the first year of gymnasium. The developers of i-textbooks, which were selected based on the conditions set out in the public call for tenders, will prepare i-textbooks for Slovene, English and German as a second foreign language (primary school), fine arts, musical arts, geography and history. Textbooks will be ready by the end of 2014.

We plan to continue making i-textbooks for homeland and civic culture and ethics, German language (for secondary school), sports (for primary school) and science (for secondary school), which will be ready by the end of this project (April 2015).

I-textbooks, prepared in the framework of the "E-school bag" project, cover the full curriculum for each subject for a specific class or grade. They must correspond to the required substantive-didactic, technical-organizational and design requirements. With interactive and dynamic elements we will provide a better presentation of facts and achieve deeper understanding of content and active participation of students. Textbooks will be confirmed by the Council of Experts for

General Education of the Republic of Slovenia and will be able to replace confirmed printed textbooks. Textbooks will also be available free of charge on stationary, portable or tablet computers and other mobile devices. They will function on all operating systems (IOS, Android, Windows).

Textbooks will be tested in schools, which are included in the pilot project "Uvajanje in uporaba e-vsebin in e-storitev" (Implementation and use of e-content and e-services) for projects "E-šolska torba" ("E-school bag") and "I-učbeniki s poudarkom naravoslovnih predmetov v OŠ" ("E-textbooks for science classes in primary schools") and the pilot project "Preizkušanje e-vsebin in e-storitev" (Testing of e-content and e-service) included in the projects "E-šolska torba" ("E-school bag") and "I-učbeniki s poudarkom naravoslovnih predmetov v OŠ" ("E-textbooks for science classes in primary schools").

The pilot projects "E-šolska torba" ("E-school bag") and "I-učbeniki s poudarkom naravoslovnih predmetov v OŠ" ("E-textbooks for science classes in primary schools") include 92 teachers from 14 schools, and the projects "Preizkušanje e-vsebin in e-storitev" (Testing of e-content and e-service) and "I-učbeniki s poudarkom naravoslovnih predmetov v OŠ" ("E-textbooks for science classes in primary schools") include 147 teachers from 44 schools.

With these pilot projects we want to determine whether i-textbooks contribute to better knowledge of students in comparison to traditional textbooks. For this purpose we will perform qualitative and quantitative evaluation. The evaluations will include quality of i-textbooks (advantages over the classic), the impact of i-textbooks on learning and the impact of i-textbooks on teaching.

The National Education Institute of The Republic of Slovenia provides live or distance support. This includes joint education of teachers, counselling and regular communication.

Members of school project teams are being trained to use e-content and e-services in professional meetings under the leadership of ZRSŠ consultants to develop good practice of use. They are accompanied and evaluated on learning, teaching and findings of use, monitoring and evaluation of e-content and e-services.

School project teams members:

- work on development: planning, implementing, monitoring, evaluating lessons and knowledge and skills of students in the use of e-services and e-content;
- develop new or update/upgrade existing models of teaching and learning, supported by the information technology and empower teachers and students in digital literacy;

- explore theoretical framework on the contemporary forms of teaching and learning, as well as various examples of quality practice of e-content and e-services use, which encourages development of diverse types of knowledge and skills (e.g. digital literacy, learning to learn, co-operation and communication, creativity, self reflection, working with e-resources, problem solving, critical thinking);
- learn about practice of e-content and e-services use, mobile applications and web services on devices (tablets, phones, laptops, etc.).

In the first year of pilot projects implementation (2013/14) teachers plan their lessons with the use of e-services and e-content at the level of individual learning sets. In the second year (2014/15) the use of e-services and e-content will be planned on a school year basis. The entire duration of pilot projects is divided into 6 testing periods. In each period a planned thematic curriculum unit and monitoring of classes is carried out by the ZRSŠ, followed by an evaluation at the end of each period.

Management of copyright, findings and recommendations

Taking into account the contract with the Ministry of Education, Science and Sport and The National Education Institute of The Republic of Slovenia, all developers of i-textbooks must, in accordance with the Law on Copyright and Related Rights (hereinafter referred to as LCRR)[1], transfer all material copyright exclusively, time and territorial unlimited. The Institute must then make all i-textbooks in relation to third persons (users) available under the Creative Commons license (hereinafter referred to as CC)[2]. The use of CC licence lets the users know in a clear and unambiguous way, in advance, how an i-textbook can be used. A Slovenian license version 2.5 is used for existing i-textbooks, which stipulates "recognition of authorship" + "non-commercial" + "share alike". This means that the user can reproduce, distribute, rent, make publicly available or modify i-textbooks, but the author must be named, they cannot be made for commercial use and the original work or modified version have to be shared alike. It is an approach, which has gained acclaim during the first Ministry projects, relating to the development of e-materials.

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[1] Uradni list RS, št. 21/1995, 9/2001, 30/2001 - ZCUKPIL, 43/2004, 17/2006, 114/2006 - ZUE, 139/2006, 68/2008, 110/2013.

[2] More information on CC licenses is available at: http://creativecommons.si/licence.

This raised some questions from the manufacturers of i-textbooks as well as The National Educational Institute. We wondered if such a volume of material copyright transfer is necessary, if it would be prudent to use a license, which would allow commercial use of i-textbooks or limit the possibility of i-textbook modification due to difficulties in clarifying copyright, because some copyright holders, in some cases, markedly averse any further adaptations of copyright work, etc.

The need of transferring all material copyright to the National Education Institute has proven to be justified due to already known changes and adaptations of i-textbooks. Either due to change of curricula, needs for other substantive changes or due to adjustments for learners with special needs and students of ethnic minorities. A choice of a license, which allows modifications of i-textbooks is crucial for the fulfilment of one of the essential attributes of i-textbooks, since it enables teachers to legally use and adapt the content of i-textbooks for the needs of lessons, examination, etc. In the future, it would perhaps be wise to consider free license, which would allow commercial use of i-textbooks, since it would most likely further stimulate interest in upgrades of i-textbooks.

Dilemmas in management, especially in clarifying copyright, have also occurred due to low awareness and knowledge of copyright of all actors involved in a rather new area (e-educational content) and modest jurisprudence. The lack of Slovenian legislation makes clarifying copyright even more difficult since the LCRR does not follow the needs of different copyright arrangements in the case of education (i-textbooks, use of e-content in class, etc.). For printed textbooks this is quite straightforward, since the law[3] explicitly provides a legal license. In this way, it is possible, without a transfer of copyright, but with a payment of remuneration, to reproduce parts of copyright works as well as individual work in the areas of photography, fine art, architecture, applied arts, industrial design and cartography, in the case of already published work of multiple authors. In the case of printed textbook rights are therefore clarified by a collective organization, the Association of Slovenian authors (ZAMP)[4]. The needs in the educational sphere should certainly be taken into account with the changes of LCRR in the future.

In the management of copyright for software, we followed the need for a free access and long sustainability (in terms of upgrades and maintenance) regardless of the time limit on the project (as a result, a time-limited funding). The most appropriate license for open source software has proven to be the AGPL 3.0 license, which is applied to all software produced in the framework of the project. This

[3] 47th article of LCRR (lessons, periodicals).

[4] ZAMP is a collective organization, which in accordance with LCRR collectively protects and manages rights of authors and works of literature, science and publishing and their translations.

license allows commercial use and any further adaptations, which should allow upgrades of the software outside of project frameworks, which are, as we have said, time and financially limited.

Conclusion

Due to rapid development of digital technology we require different options in technical, cognitive and social field to perform tasks and solve problems in a digital environment of our everyday and working lives.

The "E-school bag" pilot project is based on three areas:

– establishment of an e-learning environment (appropriate infrastructure and e-services),

– development of appropriate e-content (i-textbooks),

– teacher training and pilot projects.

Establishment of a complete platform and development of an example of an interactive textbook, which are in accordance with the renovation of the pedagogical paradigm (the didactic-pedagogical work) and with the current guidelines of information systems (technological and licensing), brings a new freshness in the Slovenian educational environment. The implementation of the project, in a wider European context, is seen as a gap reduction in the level of development of various regions, since the Slovenian environment is, in comparison with some other areas in the EU (mainly North and West), unfortunately, unable to produce the same or similar solutions. The establishment of planned e-services, e-content, pilot projects and equipment will strengthen the competitiveness as well as innovation of the Slovenian educational environment. To ensure sustainable development of the entire platform, as well as content, all planning is done on the basis of a licensing model, because it allows implementation of new business models for both publishing houses and our country. If we titled the activities of informatisation in the Slovene educational institutions as "Slovenian e-education 1.0", we can title further activities, which are beginning to use contemporary global ICT trends (cloud computing, GRID computing, interoperability based on HTML5, use of mass devices for accessing e-content, such as tablets, smart phones, mini laptops, etc.) as "Slovenian e-education 2.0 " or with an appropriate metaphor as project "E-school bag".

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