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Electronic textbooks in natural science education – research, development and practical use at schools

Introduction

One of the strategic objectives of the information policy is certainly the adaptation to the needs of the information society of the 21st century. The challenge for the area of education is to secure adequate information literacy within the frame of secondary education. It is needed in the context of this long-term goal of education to build necessary information infrastructure of education and ensure the integration of information and communication technologies into all parts of the educational process.

The main objectives embodied in the documents of the Ministry of Education in the area of information and communication technologies are:

- Each elementary and secondary school should be equipped with at least one multimedia computer connected to the Internet which would be freely accessible to the pupils and teachers.
- Assign the coordinator of ICT in schools.
- Equip each secondary and larger elementary school with at least eight computers connected to local network.
- Full integration of ICT into the educational process at all school levels.

The majority of primary and secondary schools have modernized and well--equipped classrooms nowadays, especially for the computing and informatics. However, the use of information technologies only slowly promotes in other subjects of the curriculum. In this context it also offers the implementation of new alternative forms of education in schools (e-learning, electronic textbooks and other electronic gadgets, project teaching).

New technologies in education contribute to the elimination of often stereotype, mechanical work of teachers, and create preconditions for the creative and students' motivating activities (Lopušan, Ligas, 1997). The implementation of information and communication technologies (ICT) in education also leads to the change in the role of the teacher. It can be found labelled in the specialized literature as manager, facilitator, actor, director, designer, project manager (Loveless, DeVoogd, Bohlin,

2001). This transformation can take one of two basic forms – the teacher performs in the relation to the pupils as a mediator or as a partner (Šeďová, Zounek, 2009).

Multimedia approach to teaching includes the use of several media components such as graphics, animation, audio, text and video simultaneously. The user gets information by multisensory experience driven by its own decisions using both static and dynamic components. The clearness just as motivation of pupils is supported in the full extend. Researches show that 87% of information we receive by vision, 9% by hearing, 4% by other senses. It has been proven that a person remembers 10% of what he read, 20% of what he heard, 30% of what he saw, 50% of what he heard and saw, 70% of what he said and 90% of what he did himself. This indicates that we must provide students with visual and audio-visual materials as much as possible and give them the opportunity to fulfil themselves (Petty, 1996).

The term "multi" can be found in dictionaries and encyclopaedias as a word meaning a multiplicity or many. The word "media" is often associated with the word "resource", "environment", "environment intermediate" or "intermediate entity" (Pejsar, 2003). In the modern sense multimedia is defined as the integration of text, graphics, audio, animation and video in order to convey information (Sokolowsky, Šedivá, 1994). The term "multimedia" has become the slogan of the 90s in the field of electronic data processing. The concept of what is covered by this term differs. Most of the time this term is considered as the use of various media to make convey of information by computer more effective (Sokolowsky, Šedivá, 1994).

Multimedia is one of the most effective forms of communication, search of information and the presentation of new concepts and knowledge, because it combines together all types of media. Good multimedia title can provide a better experience than the individual media separately, because it may include movies, books and magazines which can include pictures, animations, videos, audio and text.

Furthermore, multimedia has one crucial characteristic in addition: interactivity. It means that it is not passive, but allows mutual contact and is susceptible to our reactions (Fazekašová, 2003).

Multimedia in science education

In the natural science education multimedia applications are incorporated into the education with the goal of making mastering of a subject matter more effective and improving the educational process. The lesson is not only a simple interpretation of the teacher, but it is a cooperative activity of the teacher and the pupils using a variety of teaching methods, using specific didactic resources.

Multimedia in the natural science education can convey the information which is more challenging for adoption for students. They can better visualize the abstract concepts they hear for the first time. It also serves as a motivation aspect of the lesson. The natural science lessons can include video projections, computer presentations etc.

The elements of multimedia applications can be incorporated to encounter teacher's explanation (images, diagrams etc.) in the natural science lessons. In the case of insufficient equipment of the biology classroom or laboratory, or at absence of natural biological/geological materials, it is possible to use multimedia to demonstrate the simulation of given experiments to the students. Another way to use multimedia software is to provide it to the students for self-learning.

The advantages of using modern ICT in teaching of the general education subjects

Creative work based on computer technology develops mind of the student who always has to think about how he will accomplish his plan and how he will achieve his concept. If he fails, he must think about what went wrong and why it did not happen the way he expected and wanted. The computer facilitates inductive and deductive approach of creating knowledge and along with computer modelling and data processing it offers combination of these procedures.

Computers help to reduce the risk of failure in school, fear of our own shortcomings and failures. Motivation and focus on learning is the key factor for the acquisition of basic skills and confidence building of the student. Some students who still did not show any significant talent, show up as more successful at the work with computers than their coevals. The work with computers has influence on strengthening their self-esteem. Students with little motivation from classical ways of work in school may be inspired by the education with computers, which contributes to strengthening of the confidence by success.

Working with a computer can make a positive contribution to solving learning problems with students with mild brain dysfunction (especially dyslexia and dysgraphia). For these the computer can help to overcome problems associated with learning and gives them the opportunity to at least temporarily get rid of stress which they are constantly exposed to in school. It also creates better conditions for establishing feedback and more effective communication between teachers and students with learning disabilities.

The multimedia application of the curriculum allows to shorten the time dedicated to the study of a concrete topic. It also increases the proportion of self-study associated with active acquisition of knowledge and creates space for a differentiated approach to the pupils with the emphasis to respect individual pace of each student.

Another equally important aspect is the formation of the student's personality in terms of influencing independence, curiosity, systematic work and logical thinking.

The results of the research about the multimedia presentation of the biological curriculum in primary and secondary schools

The research carried out in 2014 in the Czech Republic primary and secondary schools has been aimed at the understanding of how the information technology is used in the natural science education. It has been focused mainly to find the conditions of multimedia presentation of the biology curriculum and the usage of multimedia software in education. The need of processing of electronic textbooks has been also followed.

We have used a specific method of educational research – questionnaires. The questionnaires included structured (closed-ended) and unstructured (open-ended) questions and combined items as well. Also scaled questions have been used to describe and highlight all the essential aspects.

At the end of the questionnaire there was a place for further suggestions and comments on the current state of the use of multimedia software in schools and for stands on electronic textbooks. Individual items tried to find the respondent's school type, if the multimedia software is used during the education, and if it corresponds with the content of curriculum given by curricular documents. Questions have also been posed focused to in which didactic phase of the lesson and for what purpose does the respondent use the software. Other items watched the spectrum of multimedia software used in the schools and were focused on their strengths and weaknesses or problems which arise during the usage of the software. At the end the questionnaire survey led to map the reasons which lead teachers to refuse support of computer education at each school subject, particularly in natural science and/or biology. On the other hand, as the teachers often create their own electronic materials for teaching (mainly in form of a PowerPoint presentation), space to show interest in electronic textbooks was also given in the questionnaire.

The structure of the respondents

Respondents were faculty teachers from the primary and secondary school, and other educators who collaborate in the implementation of education practice at the Charles University, Faculty of Science. They were not only teachers from Prague and Central Bohemia, but these information has also been provided by teachers from various regions of the Czech Republic. The evaluation of the survey included a total of 157 respondents.

Among the respondents of the questionnaire survey there was 19% of primary school teachers, 14% of four-year secondary school teachers, 27% of secondary school teachers and 41% of secondary technical school teachers (Figure 1).

Among the respondents there were 92% of science teachers and 8% of humanities teachers.

Most of the respondents was qualified (Figure 2) to teach natural history or biology (54%). From other science subjects, chemistry had most of the appearances

(35%), then mathematics (19%), ecology (14%), geography (14%) and physics (11%). 14% of respondents were teachers of specialized biological subjects, like florists, geology etc.

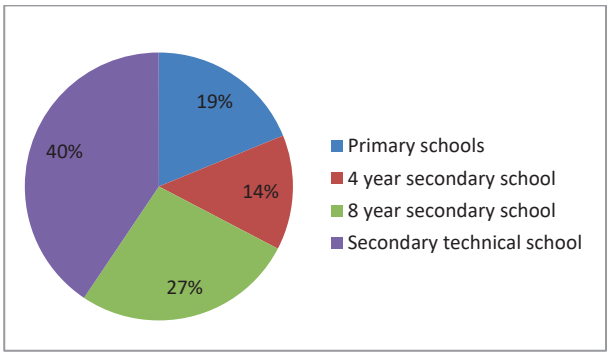

Fig. 1. Structure of the respondents (schools) in %

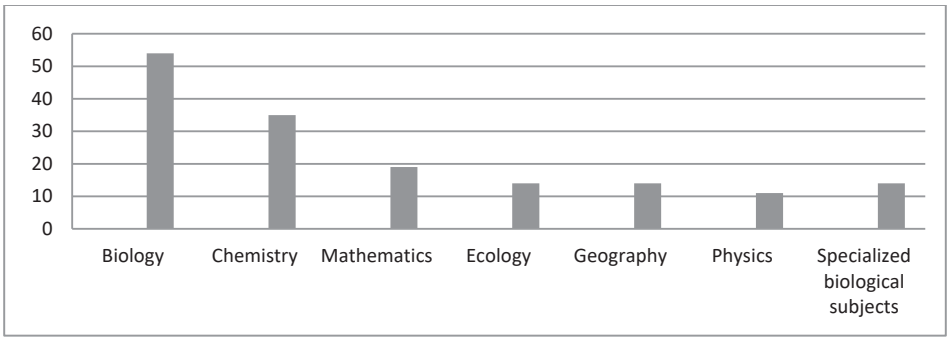

Fig. 2. Structure of the respondents (subjects) in %

Using multimedia applications in school teaching

46% of respondents said that multimedia educational software is used rarely in their classes. 27% of respondents use them very often, but the same part of respondents (27%) has never used multimedia educational software (Figure 3).

As many as 78% of respondents believe that it is needed to select only parts of the educational software due to the time restrictions. 41% of respondents are of the opinion that the content of available educational software has to be adjusted. Only 11% of respondents said that the content of available multimedia educational software completely corresponds with the subject matter in textbooks and curricular documents. In contrary, 1 respondent said that it does not correspond at all (see Figure 4 for summary).

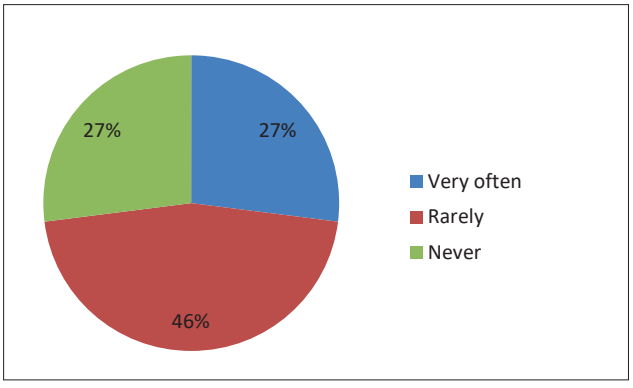

Fig. 3. Use of multimedia applications in school teaching in %

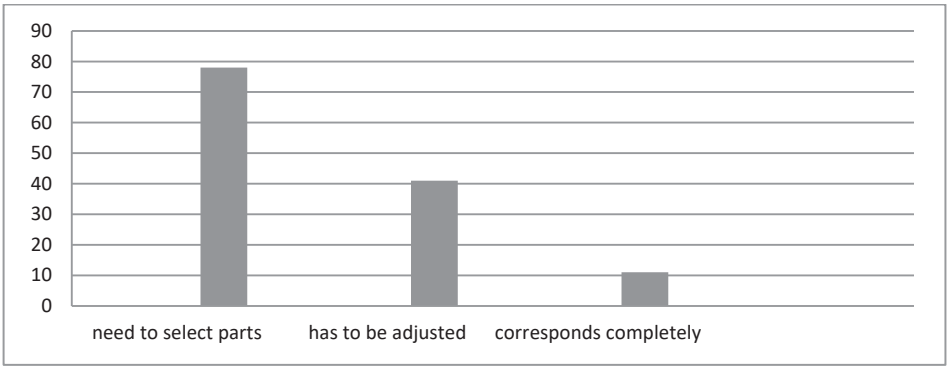

Fig. 4. Correspondence of multimedia educational software with curricular documents

Which topics or parts of biology seem to be suitable for use in multimedia software?

Botany and/or zoology have been proposed by 33% of respondents, human biology by 19%, and some themes of ecology and environmental protection by 13%. Additionally, 11% of respondents points to immunity or health education. A lot of opinions were presented but they don't occur more than in one questionnaire. 22% of respondents consider all topics without exception suitable for multimedia processing (Figure 5).

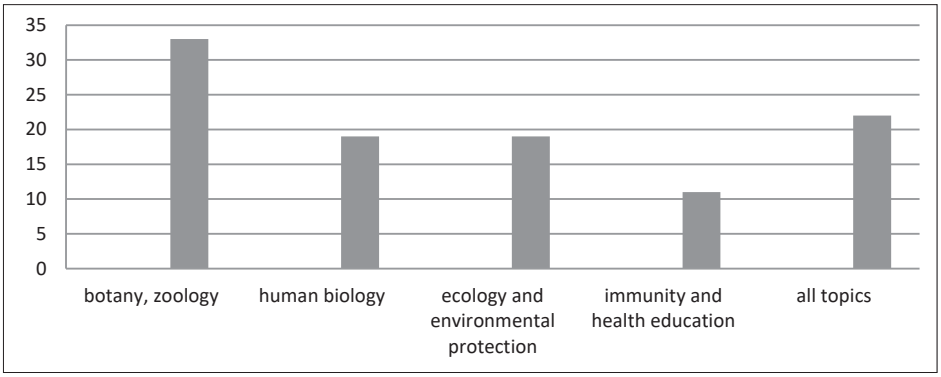

Fig. 5. Topics of biology suitable for use in multimedia software in %

Benefits of using multimedia software for teaching

89% of respondents agree that multimedia educational programs support clearness of the subject matter (Figure 6). Other responses were very diverse. More respondents agreed that multimedia educational programs are attractive (19%) and motivational (19%) for pupils. 15% of respondents see the advantages of multimedia educational programs in class enrichment, 15% see advantages in time savings in the teaching unit and making teachers work easier. Another 11% of respondents said that the multimedia educational programs facilitate more effective evaluation of students' knowledge.

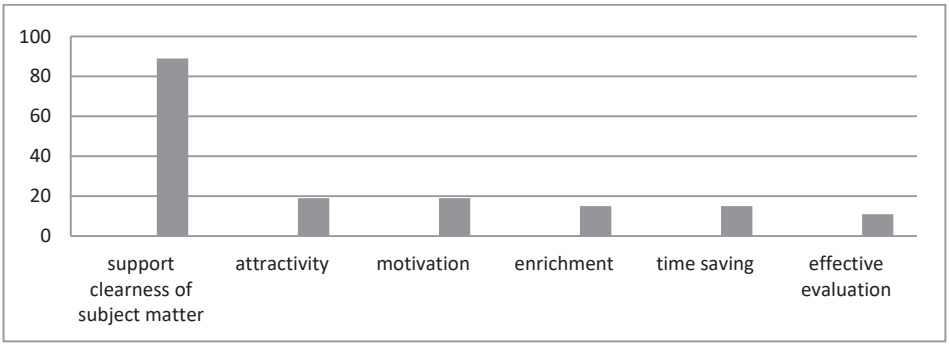

Fig. 6. Some benefits of using multimedia software for teaching

Other advantages of the multimedia are the support of the trend for individual work of students (38%), e.g. in the preparation of papers or individual verification and repetition, and also use to diversify, expand, complement and update the subject matter (38%). 13% of respondents see advantages in computer skills practice. Use of animations (25%) is also strongly appreciated.

When analysing the questionnaire research an interesting point of view occurred which emphasizes the advantage of multimedia cohesion with hypertext, pointing out that "this is the true biology".

Evaluation of deficiencies of multimedia software – what problems arise in its use?

The question focused to deficiencies of multimedia software has shown a large number of diverse responses. Among them (Figure 7) 22% of respondents identify price as a major disadvantage of educational multimedia software. 19% stated that the multimedia educational software does not correspond exactly with the content of subject matter, and therefore its use in teaching is rather time consuming. 15% consider preparing lessons using multimedia as too demanding. 11% of respondents point to the fact that educational programs contain a number of errors as their authors don't have any classroom experience, moreover, in their motivation rather finances are more important than the quality of teaching. Furthermore, difficulties were noted, related to the lack of appropriate educational technology, or to the low ability of teachers to use it for teaching.

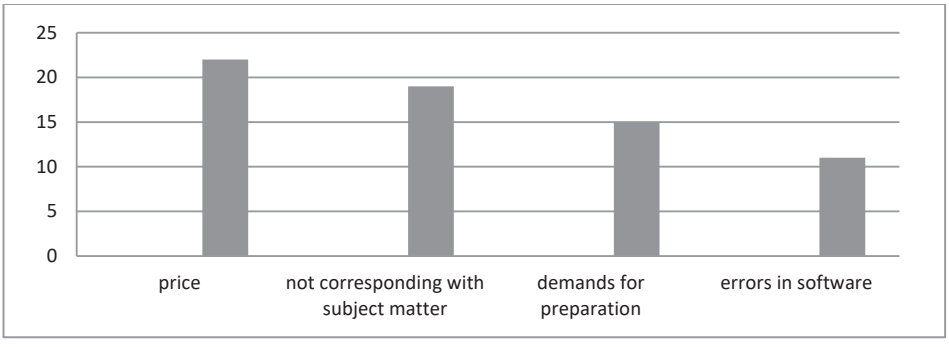

Fig. 7. Deficiencies of multimedia software in %

38% of respondents refer to spelling or technical errors caused by inaccurate translation into Czech language. They also lack a professional review of multimedia programs. Errors in the answers to the questions in tests were also noted. As a significant lack of multimedia programs 38% of respondents considered the fact that they are time consuming as compared to the content and scope of subject matters in natural science and/or biology, as well as time allocation to these subjects. Some respondents (13%) believe that multimedia programs can be effectively used in a small group of students, however, in school praxis commonly classes are not split into two groups in the natural science subjects.

Why is multimedia not used in schools?

For 39% of respondents multimedia software is not available in their schools. 32% of respondents see the reason in lack of time in the class. 11% of respondents don't have necessary hardware in the school and the same number of respondents believe that the reason is in the discrepancy between the educational content of programs and the subject matter (Figure 8). Answering this question, 39% of respondents didn't choose any of possible alternatives. Most of respondents also didn't use the possibility of free answer.

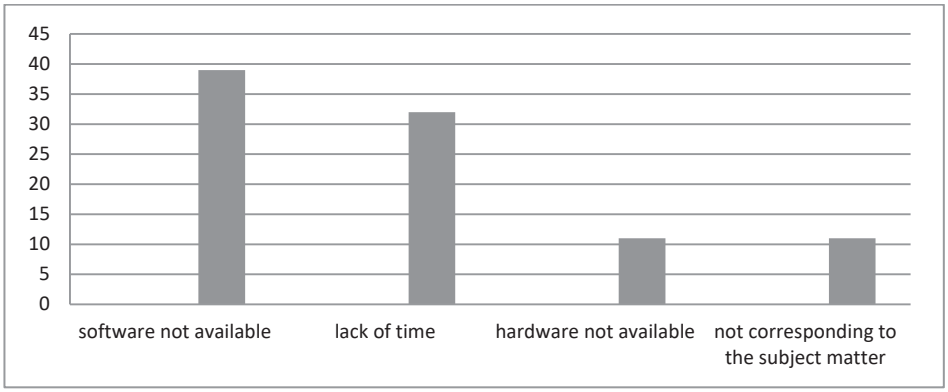

Fig. 8. Why is multimedia not used in schools? (in %)

Summary of the results

Results confirm that a methodical basis is needed for the use of multimedia applications in teaching natural history and biology. Another related research showed that teachers more often replace multimedia education software by creating their own multimedia aids focused to the specific lessons. This observation is supported by the fact that as much as 78% of respondents believe that it is necessary to select only some parts of a multimedia educational program for use in a lesson, because of time saving. 89% of teachers perceive the greatest advantage of multimedia educational programs in support of clarity of the subject matter.

Electronic textbook of biology for the secondary schools

Following the results of the survey mentioned above, in 2014 processing of electronic textbooks on natural sciences has been started (Figure 9). Electronic textbook of biology and geology was created in 2015 as an output of the ESF project aimed at promoting science and technology education in the Olomouc region. Teachers of secondary schools have been the authors of this electronic material.

Biology textbook for secondary schools was created in 2015 as an output of the ESF project aimed at promoting science and technology education in the Olomouc

region. Teachers of secondary schools – technical, as well as grammar schools – have been the authors of the e-textbook.

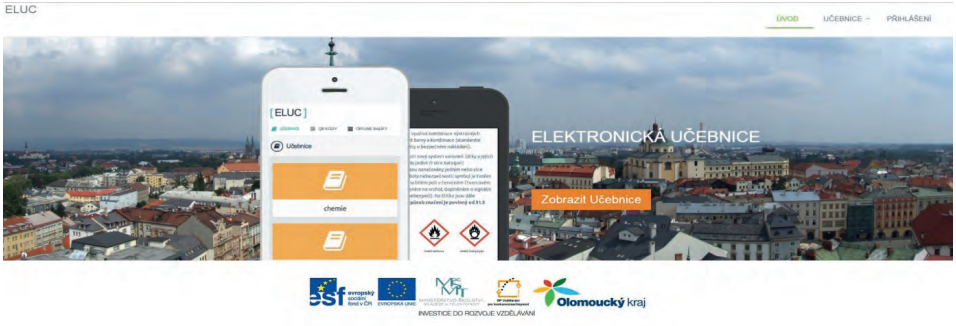

Fig. 9. Introduction to database of electronic textbooks, https://eluc.kr-olomoucky.cz/

As an electronic textbook is considered a computer application that enables touch way to browse multimedia and interactive texts. Furthermore, such one connects traditional reading, listening, video and animation with interactive elements as hypertext links, interactive charts, simulations, internet resources and, in the best, with the social networks for learning. It is not just an e-book, but it allows the student to insert his own notes, share them with other participants in learning and get feedback. Equally important feature is also the flexibility and the ability to change the content, form and way of textbook use by student and teacher. Another advantage is the ability to search and process information outside of school, i.e. at home or in the field. In this way an electronic textbook encourages the student to develop his interest to discover.

Like a printed textbook, the electronic textbook consists of the course presentation (verbal and graphical), guidance tools and tools for the evaluation of the subject matter. From a technical point of view it is linked with the school's online learning environment. Schools can take advantage of volume licensing, as well as financial advantages. The textbook is platform independent, accessible from all major computing platforms (Windows, Apple iOS, Android). Another significant features are the possibility of cooperation and sharing (e.g. through educational social networks), fulltext search, annotations (it replaces the classic notebook) and connection with other online tools. Using portable devices students have access to an electronic textbook anywhere and at any time. Technical support for the use of electronic textbooks are also tablets, which were schools in the project feature. When using electronic textbooks, as well as other products, copyright laws must be strictly respected.

Textbook structure

Key topics correspond to the names of the individual thematic areas listed in the Framework Education Programme. The textbook uses a range of flexible elements

such as hyperlinks, images, videos. To motivate pupils, curiosities and suggestions for research activities are included. For the evaluation, tests with closed items and multiple choice answers are integrated. A part of the textbook is also dealing with inanimate nature (geological sciences) (Figure 10).

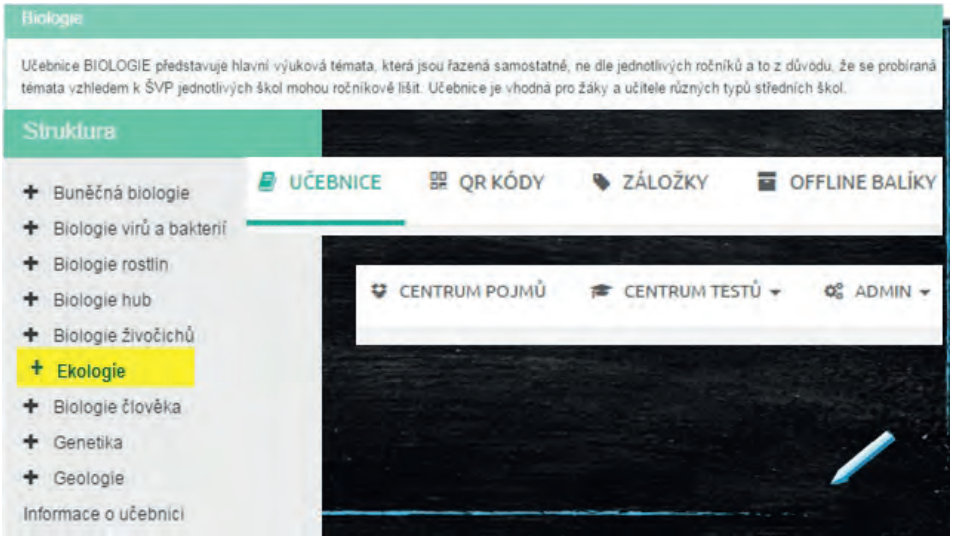

Fig. 10. Electronic textbook – title page

As an example of the processed topic ecology can be shown (Figure 11). There is the subject matter structured unconventionally and some topics are included, that seem to be up-to-date, but are not commonly found in textbooks. As examples, ecosystem management and genetic and ecosystem biodiversity can be mentioned. The topic "Ecosystem services" leads students to a new point of view on ecosystems, different of the common approach based on natural science only. It also points to the economic and social aspects of the functioning of ecosystem mainly in terms of sustainable development.

The role of ecosystems is evaluated not only in terms of science, but also services are shown that are provided by ecosystems to people. In the main of them are included: provisioning, regulating, supporting and cultural services. These interconnection aspects of natural and social sciences contribute to a paradigm shift in traditional perceptions of ecosystems. Through tablet, students can search and add other information on the topic (Figure 12).

Abiotic factors are compiled in a tabular overview with reference to subjects that give explanation to them in detail. Then biology is dealing with impacts on biota.

Fig. 11. Chapter on ecology shown on a tablet

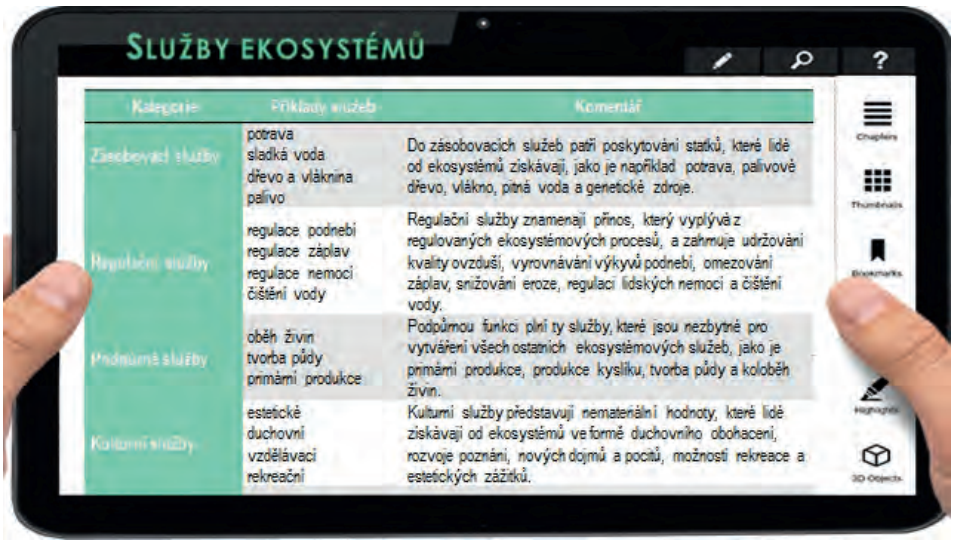

Fig. 12. Part of ecosystem services shown on a tablet

Conclusions

The teachers of natural science subjects perceive the greatest advantage of multimedia applications in support of clearness of the subject matter. Particularly positively they evaluate the use of animations of biological processes, which seems to be irreplaceable by other teaching methods. The multimedia programs, mainly electronic textbooks and textbooks' support, are qualitatively new approach to

learning, especially to active learning. The electronic textbook presented here is the first Czech biology (and geology) textbook for secondary schools that fully enables students to apply skills with modern technologies. Electronic textbooks meet the parameters of the texts of the new generation.

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Electronic textbooks in natural science education – research, development and practical use at schools

Abstract

The article focuses on specifics of electronic textbooks, their didactic parameters, selecting and structuring the curriculum. The creation of electronic textbook in biology (and geology) for secondary schools reflected the research made on grammar schools in the Czech Republic focused on use of ICT by natural science teachers in their lessons. The core of the research was the computer literacy and also the choice of subject convenient for electronic processing.

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