Abstract

The main aim of this contribution is to introduce the potential that modern information technologies open to authors converting a teaching material from a printed to an electronic version. The authors come out of their own experience and propose options that are suitable especially for creation of study materials in mathematics education. Among others the contribution presents the use of flash animations, java scripts and Computer Algebra Systems.

Introduction

The second half of the twentieth and beginning of the twenty-first centuries are the time of massive development of information technologies as well as other branches of human activity. The amount of information that we come across every day does not allow anybody “to know everything”. School, however excellent it may be, cannot hand on to its pupils all the information that they will need in their lives. That is why we must ask what one of the main functions that the school has in education process is. In our opinion it is to build a solid base on which the students will be able to build in the process of their life-long education. An integral part of this base is the ability to search for relevant information, to understand this information and the ability to further process it. In the time of an easy access to information sources on the internet this undoubtedly includes work with texts in an electronic form.

Many materials that can be found on the internet are mere publications of texts (e.g. [1] and [2]) that are of exactly the same form as the printed original. They do not make use of the unique possibilities that the interactive nature of electronic materials, their interconnectedness and the possibility to combine information from more sources offer. Undoubtedly even this type of materials is useful, if for no other reason, then for being accessible to a larger number of readers/users than in the case of the printed version. However, the goal of this contribution is to introduce materials and possibilities that opportunely use the advantages connected with modern information technologies.

If pupils and students are to be motivated to a meaningful use of computers and if their ability to look up and process information that they find in electronic form is to be developed, they must get familiar with these processes already in the time of their studies. We must prepare for them such environments and contexts in which the advantages of information technologies come to light and which offer to the users untraditional but very effective sources of new information. An active use of electronic educational texts is an efficient tool in this effort.

E-books

E-books represent the simplest form of using ICT. A book is converted – exported, or scanned into an electronic format and made accessible on the internet, or distributed on digital media, usually CDs and DVDs. Distribution of a book in an electronic form has the following principal advantages – price (the price of an electronic copy of a book is usually lower than price of the printed version), time (the book can be delivered almost immediately after the order) and environmental (no paper is needed, distribution of a book in its electronic form unless it is printed by the end-user contributes to sustainable growth). Another advantage of distribution of a book in an electronic form is that the end user may read the book not only on his/her personal computer, but also in his/her PDA and special readers. Many of these readers offer a function that is not available in case of a printed book – full text search.
The main problem connected with distribution of books in an electronic form is the problem of copyright and payment of authors’ royalties. Attempts to find a way out of this problematic situation are being made (see [3]). For example the server Books.Google.com makes it possible to state in advance what proportion of the book can be displayed on the internet, and this including the possibility to set different rights in different areas. This server also offers detailed tracking of how many times a book was displayed on the internet.

![Report from books.google.com](image)

**Hypertext links**

A great advantage of books in an electronic version is that besides full text search they enable the use of internal and external hypertext links. This enables creation of active tables of contents, indexes and links to other parts of the text within the book. Therefore for example if one wants to move to a definition of a term, it is possible by one click. The use of internal hypertext links significantly simplifies and speeds up work with the text.

E-books can also provide links to other sources, up-to-date data or search engines directly on the internet. Thanks to this the content of an e-book can by far exceed the content of the printed version.

**Illustration, video sequences, audio samples**

Another advantage of e-books is the possibility to use pictures in a much higher number without any increase in the cost price (and consequently the selling price) of the publication. Unlike printed publications, e-books may also contain video sequences and audio samples. Video sequences may in some cases be much more illustrative than static pictures. In mathematics, video sequences may be used for example to document the change of a graph of a function in dependence on the parameter, to demonstrate the solving process of problem in 2D and 3D geometry, for modeling of phenomena such as flux of liquid or gas.

**Flash animations, java applets**

Further step on the way from a printed book to an interactive study material is the use of animations and java applets. These tools enable the user-reader to influence the content of the study material directly. He/she can change the parameters of functions, carry out simple calculations or even be tested.
An example of a Java applet is the applet created within the project Active Math ([4]) which is a part of the study material LeAM_calculus (see figure 2). It demonstrates the changes of a linear function in dependence on the parameter.

**The use of CAS**
Yet more advanced step which however demands online access to the study material is the use of Computer Algebra Systems (CAS). Linking of CAS to a study text enables

- evaluation of test questions (see project ActiveMath – [4]), simple calculations:

$$\begin{align*}
3 & \quad y = m \cdot x + b \\
4 & \quad b = 2.0 \\
5 & \quad y = -1.0 \cdot x + 2.0
\end{align*}$$

**Figure 2 – Java Applet in the LeAM Calculus course**

**Figure 3 – ActiveMath CAS console**

- input of one’s own data into prepared calculations, functioning both on numerical and symbolic level:
Characteristics of a good study material
The first and very natural way of creation an e-textbook is the division of the text into various levels of difficulty and making hyperlinks between different parts of the text. It may for example be a return to a definition of a term needed for the solution of the problem, coming back to a particular computational process when solving the mathematical model of the problem assignment, link to visualization of the relevant object or of the solved problem etc. However, a good e-textbook should offer much more:
It should enable scaffolding. This concept and technique was used already by L. Vygotsky. In its original form, scaffolding may be defined as a process wherein the instructor, or a more advanced peer, operates as a supportive tool for learners as they construct knowledge. In case of an e-textbook, this role is partially taken over by the computer. For example a solver who manages to form an equation when solving a word problem but cannot solve it can “ask” the computer for help via an integrated link to CAS and get the correct result. However, it is crucial that the solver should not rely merely on the computer but should consequently fill in the gap in his/her knowledge. Another instance may be mathematical proof. A convenient structure of links may offer a graded help, links to processes necessary for solution of individual steps in the proof etc. In consequence the teacher ceases to be the only source of all help and advice. The computer, if the e-textbook is well structured – takes this role over. The use of an e-textbook enables every pupil to use such a type of scaffolding and in such an extent that is optimal for his/her level ([8]).

It should enable continuous feedback. Continuous feedback on the correctness, purposefulness etc. of the selected processes is one of the great advantages of a well created e-textbook.

It should offer graded help which is either automatic, or only on request, including automatic changes in the displayed content.

It should enable the teacher to monitor how pupils cope with the given topic, where they face difficulties, where they need help and on what level. This function, however, requires the teacher to have an immediate access to what the pupils are doing at a particular moment.

Conclusion
This article presents some of the possibilities that modern information technologies offer when creating electronic materials. In the light of the rapid development in the field of information technologies, the presented list cannot be under any circumstances regarded as exhaustive. The authors primarily try to reflect on their own experience with creation of electronic study materials which they gained when solving projects both on national and international level.

References

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