INTEGRATING GEOGEBRA INTO INTERACTIVE ELECTRONIC BOOKS

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ABSTRACT: The paper introduces the steps of creating and publishing an interactive electronic material for geometry teaching in secondary level, using specific languages such as HTML, XML or CSS, embedded in the ePub format and using specific educational software such as Geogebra. The interactive book contains educational material covering geometry according to the school curriculum and it is dedicated to the students of the 7th grade. It contains interactive applications for each chapter and subchapter, which exemplifies the theory learned, demonstrates the stated theorems and eases the visualisation of properties of the geometric forms.

KEYWORDS: GeoGebra, e-Pub, e-book, computer-aided mathematics, educational material.

1. INTRODUCTION

Due to the fact that today accessing technology and knowledge is easily available to everyone, in the majority of schools and user homes, learning methods have changed radically. The Internet has become an impressive source of information and teaching materials that circulate, often free of charge. This virtual library enables all people, regardless of their age or profession, to learn and to self-train.

In the case of pupils, they are no longer dependent only on the knowledge and teaching methods made available by teachers or on the material available in the school manual, but they can get involved directly in the learning process and can study the educational materials themselves, as shown in Figure 1. Both individual and group study is encouraged by the new methods and brings significant benefits to the completion of the information previously acquired.

In the case of teachers, they have access to a large amount of educational materials for their fields of activity through which they can permanently enrich and update their knowledge. This way, it is easier to capture the attention of pupils, by using interactive and multimedia materials so they can be actively involved in the teaching process.

Also, there will always be the possibility of communicating and sharing the teaching experience with colleagues in the country or abroad, the Internet being a way of communication, not just information.

Modern technology has experienced great expansion over the past few years, converging through an extensive use by people of all generations. For young generations, technology has taken on an important role in social and educational life. A high percentage of students have access to computers connected to internet, mobile phones, video games and various other forms of modern technology. With the rise of technology role in adolescents' lives, there has also been a growing concern about how it might affect them. A large number of people everywhere are using modern technology. One of the most visible changes in the last decade has been the widespread expansion of information and communication technologies ([Cal11]).
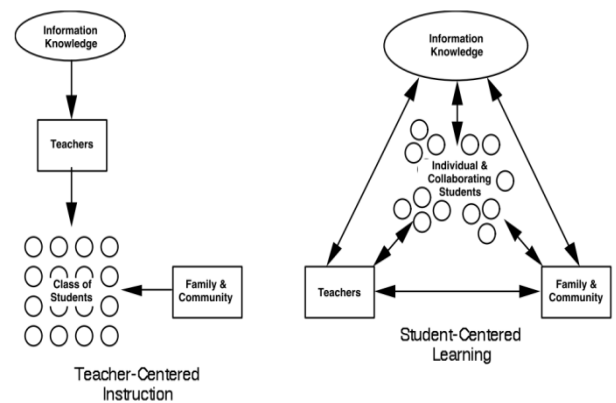

Fig. 1. Learning patterns

Also, the rapid change in content of modern technology has really expanded society's vision related to technologies as a tool for developing children's abilities and motivating them in academic fields such as mathematics, science, languages and writing. Even parents agree that modern technology is an important educational resource. Among adolescents, games are the most common in online activity.

It has been noticed that in classrooms, computer software applications, along with word processing, are the most available and used applications of educational technology. Databases and spreadsheet programs can practice organizational and software modeling skills.

The main form of the learning process is described by the authors through integrated computer-based learning systems. Teachers use new support to enrich the training and they can provide means for individual study.

Similarly, different technologies offer different types of content and are used for achieving various goals in the classroom ([Mgh15]). Electronic word processing and e-mail writing can develop communication skills, database and spreadsheet programs can promote organizational skills, and modeling software promotes understanding of science and develops math skills. Many pupils and students learn even with mobile phones.

Teachers' and pupils' activities are no longer limited to school laboratories, but they use specific devices with access to technology that are increasingly centered on the learners' experience. Technology learning improves students' judgment and problem solving skills.

With the evolution of technology and the time passing, common, traditional things have been adapted. For example, books. Unlike a printed book, an electronic book is more "flexible", which means it can be manipulated in various ways. Printed books and classic text-based electronic documents are essentially static.

2. MODERN TECHNOLOGIES AND EDUCATIONAL MATERIALS

2.1 Cloud Computing

Cloud Computing is a modern concept in the field of computers and informatics, representing a distributed set of computing, applications, access to information and data storage without the need of user to know the location and physical configuration of the systems that provide all these services.

Among the benefits, one can mention the much simplified synchronization of user data that uses multiple cloud-related devices (PC, smart-phone, tablet, etc.). When working in groups (teachers or students) using the same documents, the people involved have access to them regardless the location. Cloud computing also helps teachers in building and distributing digital learning materials and educational activities for their students. The materials can be created by teachers or they can be assembled from a resource repository created by other teachers in the network.

Documents can be processed by using a great variety of web applications. The computing speed and storage capacity are increased and they are independent of the user's hardware configuration or the possible local storage defects.

Although, we have to highligth a major drawback of cloud computing, namely the user must have access to the Internet all the time, and data security is not 100% guaranteed.

2.2 Mobile Learning

Mobile learning focuses on learning by using mobile devices (smart phones, tablets, laptops, etc.) anywhere and at any time. Mobile learning is defined as "learning in multiple contexts, through social and content interactions, using personal electronic devices."

Its clear advantage is its mobility, each student and teacher having their own mobile device, configured according to individual preferences. Choosing the installed applications would only depend on the user's needs. Computer laboratories in educational institutions would disappear, no need for a sustained room for personal computers only.

2.3 Massive Open Online Course and Open Content

MOOC is an online course that is designed to be followed by an unlimited number of people over the Internet. Compared to traditional courses offering videos, reading materials and sets of problems, MOOCs also offer interactive forums where students can interact with each other and with the teachers. The MOOC phenomenon is relatively new on the stage of distance learning and emerged in 2012.

The use of open content promotes a set of skills that is essential to ongoing development in any field of study - the ability to find, evaluate, and make new information available to users.

For example, an open content site may be described as a site under continuous construction. The more authorizations are granted to the general public, the more open will be the content. But it should be noted that any posted material is first verified by the site administrators.

2.4 Game-based learning

The concept of play has crossed the field of recreation and has penetrated into trade, productivity and even education, proving to be a useful tool of training and motivation.

Game-based learning is a type of game that results in learning. Generally, it is designed to balance the proposed material with the game and with the ability of the player to retain and then apply the subject to the real world.

Here we can list all the standalone educational applications that run directly under the operating

system and those that are embedded, for example, on web pages, electronic books, etc.

2.5 3D Printing

We are mentioning here the process of making a three-dimensional object starting from a 3D model or other electronic data source primarily through additive processes in which successive layers of material are set under computer control. A 3D printer is a type of industrial robot. 3D printing is the latest technology introduced in schools. It allows students to design and produce real models or prototypes, which then can hold them in hand. All this, without the need for a wide range of tools, materials, and obviously time to manually create the respective models.

For example, it can be used by students to recreate museum objects such as historical fossils and artifacts for classroom study (without affecting sensitive collections), to build complex models with moving parts, topographic maps, cross-sections of organs internal human body, 3D models of molecules, etc.

2.6. Virtual and Distance Labs

These kind of labs were conceived to provide flexibility to students who can run experiments, both in school and outside school. Because these virtual laboratories allow easy repetition of experiments, students do not feel the pressure because they do not have to perform perfectly from the first time they run the experiment. In the environments controlled by these virtual laboratories, students are safe, even if they make a mistake. Moreover, students can simulate experiments that can be dangerous in real life or require expensive materials.

Here we can talk about a wide range of simulation software: from chemical reactions, genetic combinations, weather conditions to virtual computer networks.

As the evolution of technology is experiencing an exponential growth, many other educational technologies will emerge over these years. It is only up to us which of these we will implement, which will be most useful for students and teachers alike.

3. CREATING ELECTRONIC BOOKS

An electronic book is a virtual book, a digital publication, consisting of text, images, or both, which may include video, sound and also scripts. It can be defined as an electronic version of a printed book, although it often does not have a printed equivalent.

Electronic books produced and sold commercially are usually designed to be read with the help of dedicated readers, however, almost any electronic device that has a controllable viewing screen, including computers, more many mobile phones as well as all smartphones can also be used to read books in electronic format.

E-readers have a weight comparable to a true book, can be carried everywhere, offer a low battery consumption, even up to a month, depending on technical features and give a great mobility. They are made to simultaneously contain large amounts of information, even hundreds of books and documents. Their storage can be made directly on the device's internal memory or by using an Internet connection on dedicated sites.

In the late 1990s, electronic readers have gained popularity due to electronic paper inventory, a technology that allows the display screen to reflect light as regular paper, and without the need for backlighting.

For this reason, a consortium has been formed to introduce a common standard and develop the Open eBook format as a way for authors and publishers to provide a single source document that can run on different readers regardless of the software or hardware platform.

In brief, an open eBook is a .zip file connected with a Manifest file. Inside the package one can identify XHTML-defined subsets that can be used along with a CSS file and metadata files. It can contain a set of multimedia formats and an XML schema for a "manifest", files related with the list of components of a particular e-book, for the identification of a table of contents, a cover and this list can continue. The default extension is .OPF and it was later replaced by the ePub format.

3.1. ePub Format

The ePub format is a free ebook standard made available by the International Digital Publishing Forum IDPF (International Digital Publishing Forum). ePub has become an official standard of IDPF in September 2007, replacing the older eBook standard. ePub uses the (X) HTML or DTBook (XML standard) language to represent the text and the structure of the document's content and a subset of CSS to set the layout and formatting features. XML is used to create the document manifest, ePub content and metadata. Finally, alle these files are included in a .zip file which is the packaging format.

ePub is designed for a "flowing" content, which means that an ePub reader can optimize the text for a particular displaying device. ePub also supports

content with fixed positioning. The text is resizable in all cases.

Other features of this format include:

- the display of images in the form of pixel arrays (bmp) or through the vector graphics process,
- inclusion of metadata files that describe the contents of the ePub file,
- DRM (digital rights management) support,
- processing layout of pages and elements with CSS,
- support for audio and video content (device dependent),
- use of XML islands (out-of-line and inline) to extend ePub functionality.

For our application, we have used Version 3.0 of ePub which consists of a set of four specifications:

- ePub Publications 3.0, which defines publishing semantics and major compliance requirements for ePub publications,
- ePub Content Documents 3.0, which defines XHTML, SVG, and CSS files for use in ePub,
- ePub Open Container Format (OCF) 3.0, which defines a file format and processing model for encapsulating resources in a single ePub (ZIP) file,
- ePub Media Overlays 3.0, which defines a format and processing model for text and audio sync and XML islands to extend ePub functionality.

Of course, the are some weak points related to the ePub 3.0 format, above which we can mention that:

- it is deal for books that mostly contain text, ePub may be inappropriate for publications that require precise formatting or special layouts
- there is a lack of support for MathML-formatted equations. These aspects are currently included as bitmap or SVG images, although MathML support is included in the ePub 3.0 specification.
- the lack of details about links to, between, or in an ePub, and the lack of annotation specifications. For this reason, ePub file usage scenarios are limited, especially in educational environments, because a level of interactivity comparable to webpages can not be ensured.

3.2 Sigil

Sigil is an open-source publisher of EPUB electronic books developed as a rolling application on various software platforms and distributed by Microsoft Windows, Mac OS X and Linux platforms under the GNU GPL license ([Sig18]).

Sigil has been designed to facilitate easy creation of electronic books for personal purposes or for professional editing on multiple platforms. Sigil supports editing both WYSIWYG and ePub-based code, as well as importing HTML and plain text files.

It enables the user to format and collect books in an ePub by using a set of advanced features that made Sigill one of the most popular ePub editors. This open source and fully free software is written and supported entirely by volunteers.

Among its characteristics we mention:

- full support for ePub 2 and UTF-16;
- multiple view modes: book, code, and preview;
- WYSIWYG direct editing in the book;
- generated content;
- metadata editor with full support for all metadata entries;
- spell check with user-configurable and default dictionaries;
- supports import of ePub and HTML files, images, video, sound, style sheets (CSS), scripts, etc.
- integration of FlightCrew ePub to validate ePubs in accordance with established standards;
- Integrated HTML for external HTML and graphics editors.

Of course, Sigil also has some disadvantages, namely the program is under development and still contains enough errors, which brings many beats to the user. It is recommended that user files are saved in the workplace to prevent any loss of information entered between work sessions.

3.3 Readium

The primary objective of the Readium project is to create a reference system for ePub publishing, the ability to incorporate Readium or its components into other applications that support the ePub format. The main components of the project are the ePub reader for Chrome and the ePub reader for mobile devices.

Readium for Chrome is the configuration of the browser with the ReadiumJS extension, a read-only open source system and a JavaScript library to display EPUB publications in web browsers. It allows the user to create and to manipulate a virtual library within it, to import books on the personal computer or directly from the net by entering the URL, then removing them after reading.

The Readium SDK for mobile devices is still under development and will provide a compact and performance ePub rendering engine usable in native applications of tablets and other mobile devices.

The code is intended for all platforms and it is implemented to a large extent in native code with some JavaScript / Java / C # implementations, where appropriate.

4. GEOGEBRA E-BOOK

The developed book is written in ePub format, according to International Digital Publishing Forum (IDPF) standards and can be viewed on the computer with the help of the Google Chrome Browser by adding the Readium extension to its applications or electronic readers which supports the ePub format.

This is the first edition of this book and it is an experimental one, to be improved in the future. The book will be used to teach geometry in classrooms, but not before rigorous testing and validations on groups of students.

It is not ment to replace the printed book of geometry intended for students, but it can be used as additional educational material. Since the first edition of the book largely covers the theory, the solved problems and the proposed ones will be extracted from the printed manual.

The application consists of two main parts:

- the actual book, the .epub file that was created with the Sigil program. The sub-components of the epub archive were also processed with Adobe Dreamweaver and Adobe Photoshop. The Google Chrome browser Readium was used to view the book.
- over 30 interactive applications made in the Geogebra program and integrated into the .ePub file.

The ePub file is a complex archive that contains many documents of different types, some written in different programming languages. The components of the ePub archive contain a large amount of files and we are presenting them: XHTML, HTML, XML, HTM style files, CSS style files, PNG, JPG, GIF, SVG, font files: TTF and OTF, audio files: MP3, AAC , MPG, MPEG, M4A, video files: MP4, OGG, WEBM, M4V, various files, including standalone files, such as external scripts, .opf file, and .ncx navigation file.

Any picture used in the book must be imported into the image file inside the program. Lack of support for the ePub format for MathML equations forces the programmer to introduce mathematical formulae as images, in .png format, after they were written in a text editor, then transformed and processed with Adobe Photoshop.

This is also the main reason for the criticism of ePub developers because it prevents the use of ePub for most technical publications. Equations are currently included in eBooks as bitmap or SVG images.

The whole page layout is set by the style rules defined by the `class = "page"` declaration in the main division. It is overwritten by the rules of the paragraph which contains the title of the chapter, respectively those in the secondary division.

The style of the secondary division is overwritten again by the rules set for sub-paragraph and the text-graphic division. In addition to this, there are also local (internal) overlays that determine the appearance of some elements within those labels.

The major disadvantage of the last two is that any changes need to be made manually to each of the elements in the html files, which requires time and patience. The clear advantage of using CSS is fast document formatting and easy code access because it is in an external file:

```
<link
href="../Styles/stil.css"rel="stylesheet"
type="text/css"/>
```

We still have other two ways to integrate CSS within html: by importing a .css file from an Internet address or by including CSS code directly at the top of the page, recommended only when we have a single html file.
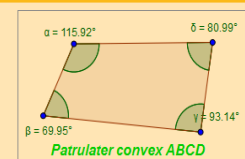
Fig. 2. GeoGebra e-book screen

To be considered a valid ePub, the eBook must meet the standards set for ePub. This means that it must include certain files and information and not contain errors according to ePub specifications. To verify that the ePub is valid, we have used several tools, as shown in Figure 4. FlightCrew is included as part of the Sigil program so it will simply display a new window under the editing window listing all the problems it finds. After the validation runs to

produce the report, each entry must be checked, then edited and corrected for each issue.

In our case, most of the reported problems could be solved, except those related to the inside of the code generated by the GeoGebra application ([Geo18]). Changing the code in any way leads to the non-display of applications within the electronic book.

The GeoGebra software enables the user to export his applications in different formats: static or animated GIF, HTML5, SVG vector images, and options for direct export to clipboard, PNG, PDF, EPS.
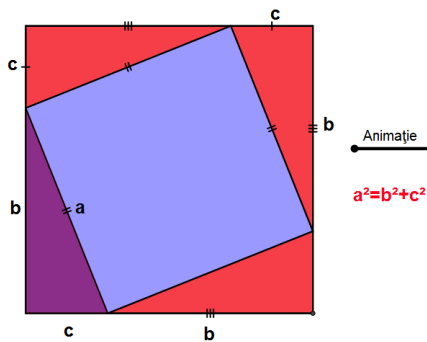

Fig. 3. Pitagora's theorem in GeoGebra

To integrate GeoGebra apps into electronic books or webpages so they remain dynamic, we have two ways to exportthem: as HTML files or by uploading them to the GeoGebraTube site.

For the current version of the book, we have chosen the HTML version because at that time there was more data on this integration mode. The GeoGebra software generates a complete HTML page from which we retrieve all needed content. The more the drawing is loaded and the more options are available, the harder it is to load the drawings, because the parameters are sent to an internet address, decoded and returned.
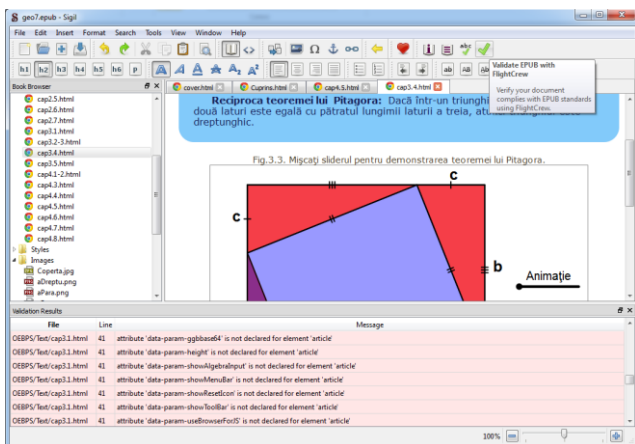

Fig. 4. EPUB validation with FlightCrew

Uploading applications to the GeoGebraTube virtual library will be more profitable in the future because

any uploaded content will have the option of embedding HTML, Mediawiki, Wordpress, Moodle and Google sites with the code being automatically generated by GeoGebraTube.

The major advantage of this method is that applications are stored directly on the internet, on GeoGebra servers and they are imported into the book or website only by specifying their address, which means faster and easier uploading. Also, HTML becomes clearer and less loaded by comparing the contents of the `<iframe>` and `<article>` tags.

The disadvantage is that we need to have a GeoGebraTube account to upload the materials and, for any necessary changes to the applications, they must be downloaded, modified, reloaded, and the old application must be replaced or deleted from the GeoGebraTube site. This disadvantage will disappear when application processing can be done directly on the site in the user's account. Both situations require an internet connection, otherwise GeoGebra applications will not be displayed.

5. CONCLUSIONS

The new educational materials have gained and continue to gain ground in front of classic ones because they have become more attractive and contain more and more interactive elements, and the nowadays student is more receptive to such a presentation.

The new generation is familiar with the "SMART" electronics and uses it frequently, which has made it easier for them to move around and transit smoothly to these new educational methods. Often, teachers are the ones who face a bigger, yet interesting challenge in this change.

But, in no circumstances, this does not mean that classical teaching methods are no longer useful. Several studies have shown that the technology used for training has relatively few direct effects on students' learning ability or motivation. Much more important is the way people learn and their motivation of acquiring knowledge, rather than the technology used.

REFERENCES

[Bed88]   **M. A. Bednarczyk** - *Categories of asynchronous systems*, PhD thesis, University of Sussex, 1988.

[Cal11]   **R. A. Calvo** - *New perspectives on affect and learning technologies*, Springer, New York, 2011.

[Geo18]   http://www.geogebra.org/book/intro-en.pdf, accessed 2018.

[JB02]   **J. Johnston, L. T. Barker -** *Assessing the impact of technology in teaching and learning*, Institute for Social Research, Michigan, 2002.

[JIS12]   *Preparing for Effective Adoption and Use of Ebooks in Education*, JISC Observatory TechWatch Series, Report No. 4, Final Version, 2012.

[Mgh15]   https://www.mheonline.com, accessed 2018.

[Nel08]   **R. M. Nelson** - *E-Books in higher education*, EDUCAUSE Center for Applied Research, 2008.

[Pin02]   **M. Pintilie** - *Metode moderne de învăţare evaluare*, Editura Eurodidact, Cluj Napoca, 2002.

[Sig18]   https://sigil-ebook.com/, accessed 2018.