

# The Development of an eBook for Teaching and Learning Mathematics

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**Abstract.** Mobile devices, smartphones, phablets and tablets, are widely available. This is a generation of digital natives. We cannot ignore that they are no longer the same students for which the education system was designed traditionally. Studying math is many times a cumbersome task. But this can be changed if the teacher takes advantage of the technology that is currently available. We are working in the use of different tools to extend the classroom in a blended learning model. In this paper, it is presented the development of an eBook for teaching mathematics to secondary students. It is developed with the free and open standard EPUB 3 that is available for Android and iOS platforms. This specification supports video embedded in the eBook. In this paper it is shown how to take advantage of this feature, making videos available about lectures and problems resolutions, which is especially interesting for learning mathematics.

**Keywords:** eBooks · Mathematics · m-learning · EPUB

## 1 Introduction

As we look toward the future of education in the 21st century, the prominence of a robust STEM (Science, Technology, Engineering, and Mathematics) curriculum is unquestioned. However, low achievement in mathematics education has been an increasing problem in the recent years in Portugal. In 2014, the average classification in the 12th grade exam, from 0–20, was of 7.8. Mathematics exams in the 1st cycle, 2nd cycle and 3rd cycle had an excessive percentage of negatives (levels 1 or 2), 36 %, 54 % and 47 %, respectively.

Moreover, according to a recent study on the changing pedagogical landscape [1] the importance of lectures in higher education usually precludes other teaching and learning techniques, such as projects, laboratories, seminars and tutorials. But there are signs that this situation is changing to varying degrees, with the introduction of new pedagogies harvesting the affordances offered by new technologies. Another EU study by the High Level Group on the Modernisation of Higher Education in 2014 [2], indicates that MOOCs and other recent innovations are only one part of a wave of change in higher education, recognizing that blended learning or other forms of on- and off-campus learning are now widespread. However, the lack of clear assistance as to how

the higher education system would need to change, in order to accommodate students needs, results in most universities being unwilling to follow high risk strategies, either alone or together.

It is also important to note that these students are the generation of digital games and social networks. We cannot ignore that they are no longer the same for which the education system was designed a few decades ago. See, for example, the prospect of Heide and Stilborne [3], for whom “the technological revolution has produced a generation of students who grew up with multidimensional and interactive media sources. A generation whose expectations and world views are different from those that preceded it” (p. 27). Online interaction has become a way of life for students wherever they are: at home, on the move, or in schools. For the institutions this is good news, as for the first time in history we have educational technologies that cost (almost) nothing to governments and schools: smart mobile phones (most students have one), networking software (freely available, e.g. Hangouts, Messenger, Skype), learning applications (freely and increasingly available, e.g. Apple Store, Google Play) and open educational resources (in growing supply, e.g. MOOCs, iTunes U, Khan Academy). There are other free tools available for learning organizations, such as collaborative tools (e.g., blogs, wikis, knowledge-building software), immersive environments (e.g. virtual worlds), media production and distribution tools, and many more.

Online activities may be accomplished, for example, through the use of mobile communication and wireless technologies, allowing for experimentation, augmented reality, image collection, map sharing, and communication with other students, anytime and anywhere. In this context it is wise to consider the integration of digital media and mobile devices (iPad, iPod, tablets, smartphones), allowing students to set personal goals, to manage educational content and to communicate with others in the right context. In the near future, eventually everyone will have a smartphone or a tablet. This will make it possible for a teacher to develop educational activities that can take advantage of mobile technologies for improving learning activities.

In this paper, we present the design and development of an eBook for STEM teaching and learning of mathematics. Students can use this eBook in the classroom or outside the classroom in a blended learning model to solve problems. When students have difficulties in solving a problem they can watch the resolution of it. In this way, we want to provide the same opportunities to low-achieving students that may struggle to learn the materials covered in class. Students have also access to complex problems that may provide additional stimulation for top performers students. In this way, we can provide a platform that is student-centered and teacher-friendly.

## 2 Motivation

Results from the 2012 Program for International Student Assessment (PISA), show that Norway, Portugal, Spain and Turkey are below the OECD average in mathematics, with a mean performance of 489, 487, 484 and 448 score points.

The countries that show significant improvement in PISA performance – Brazil, Germany, Greece, Italy, Mexico, Tunisia and Turkey – are those that manage to reduce

the proportion of low-achieving students. In Norway, Portugal and Spain about one out of four students, in Turkey about one out of two students, still do not attain the baseline proficiency Level 2 in mathematics. It means that in the best of the cases, low achievers students can extract relevant information from a single source and can use basic algorithms, formulae or procedures to solve problems involving whole numbers.

Regardless the controversy over PISA tests results, this situation calls for actions aiming at improving instruction strategies for teaching and learning mathematics.

In this paper we present an eBook that is set for improving mathematical performance and achievements for all students, including also low achievers and the top performers. The development plans for this eBook aim to extend the traditional learning environment to a virtual classroom setting that will keep students connected and effectively learning mathematics through the exploration of math tools that will enable students to practice more. This eBook enables the exploration of video lectures in smartphones, phablets or tablets.

This eBook will contribute for the implementation of a blended model for teaching and learning mathematics that will accommodate problems of different complexity and resolution with different detail. It has three different levels of problems complexity: beginners, intermediate and advanced. On the other hand each problem has two levels of explanations/resolutions: detailed and concise.

In this way, all students are accommodated in a learning environment centered in the student. The low-achieving students that may struggle to learn the materials covered in class, can study and repeat the materials as many times as they want. Students will have access to complex problems and activities that may provide additional stimulation for top performer students. Teachers will also be more confident to give homework activities to their students, to help struggling or underachieving students to learn the material covered in class, ensuring that the material is stored in students' long-term memory, or providing additional stimulation to high performers. But homework can be particularly burdensome for disadvantaged students. Their parents' may not have the skills to help them, and they may not have the resources to support them on private lessons. We aim at providing the same support for all the students so that we can contribute to improve the relationship between students' socio-economic background and mathematics performance.

### **3 eBook Authoring Tools**

There are several ecosystems and tools that can be used to create ebooks and distribute them for personal computers and mobile devices. The simplest way to create digital books, for multiple mobile platforms, is to start with PDF or RTF files and use applications, like Calibre, that converts PDF files in multiple formats such as EPUB, or MOBI for the Kindle, among others. Calibre is a free application that runs on Windows, Mac OS X and Linux.

There are other free or open applications that support the creation of electronic books. For example, the application eCub allows the creation of simple books in EPUB or MobiPocket, from text files or XHTML. However, eCub is very limited, with no

WYSIWYG capabilities. It is suitable for the production of simple ebooks with front and back pages with an image, index, a title page and it can convert content to a sound file (WAV or MP3). The eCub is free and is available for Windows, Mac OS X, Linux, FreeBSD and Solaris.

Booktype is an open platform, available since 2012, which allows editing and writing of ebooks for different platforms by exporting in PDF, EPUB, MOBI, ODT and HTML. This application also exports the ebook directly to Amazon, Barnes & Noble and iBookstore online stores, as well as to online printing sites. Digital books written with this application are immediately available in any of these platforms. When writing the ebook, the author does not need to worry about formatting, since it will automatically be formatted to work in these different platforms. Booktype also provides a set of collaborative tools for reviewers, editors, translators, designers, and authors, enabling the different participants to work collaborative in the production of an ebook. Some of the features offered by this platform include: intuitive drag-and-drop tools, chat, messages, adding images and text formatting. Booktype also maintains a history of all changes, which allows the author to compare different editions and return to a previous edition. It is even possible to use snippets (pieces of computer code). One of the disadvantages of this platform is the need for installing on a server and accessing via web browser, which requires some additional expertise.

The Firedocs eLML editor can also be used to create ebooks [4]. The eLML framework (eLesson Markup Language) is an XML platform for creating online classes using XML. It exports produced materials in SCORM, HTML, PDF and EPUB format. The main objective is to ensure that classes are modeled according to the ECLASS reference, which defines five distinct sections: Entry, Clarify, Look, Act, Self-assess, Summary. Current implementation only supports JPG, PNG, GIF and SVG images. It does not allow Java scripts and forms, so some of the functionalities as the glossary, references to labels and self-assessment tests are not available in the EPUB format.

Sigil is an open WYSIWYG editor used by Google to create ebooks following the EPUB3 specification for Windows, OS X and Linux. This application imports, creates and edits XHTML documents and exports them into EPUB3 documents. Ebooks created with Sigil may contain text, pictures and links, video or sound. It also provides multiple views of the work: book, code and a split mode. In the book view, it allows content edition in WYSIWYG mode.

Finally, we should mention the electronic books created in the iBook format from Apple. These ebooks are created with a free application - the iBooks Author tool. The format is proprietary, although based on the EPUB standard specification, with some differences in the CSS3 tags. This tool makes the process of creating ebooks very easy, by presenting a very complete set of integrated features, including: sound, image, video, dictionary, text underline, annotations, text-to-speech conversion, navigation and many widgets to enhance the interactive experience. The introduction of widgets in the iBook is an enriching experience for readers of an electronic book. iBook Author offers seven types of pre-defined widgets: (1) photo gallery, (2) video or audio media file, (3) review questions, (4) slide show; (5) interactive tagged images, to give detailed information on specific parts of an image or graph, (6) 3D models, and (7) objects created in HTML. The ease of creating widgets allows users to add any object to an interactive iBook, and

there are many possibilities, from calculators, puzzles, maps, YouTube videos, among many others.

## 4 Design and Development of an eBook for Math Teaching

This section presents an eBook that students can use to study in or outside the classroom with the produced materials in an accessible and organized way.

In this way, teachers can extend the class into a virtual class in a form of blended learning in which students can solve and visualize video lectures and home works outside the classroom. This is especially interesting for learning mathematics. If students can learn at home from watching video lectures and solving problems, time in-class can be dedicated to explore more motivating problem solving. Math teachers have a difficult situation. Studying math is many times a cumbersome task. But this can be changed if the teacher takes advantage of the technology that is currently available. Students are surrounded by multiple devices, such as smartphones and tablets, which give them access to multiple media that is easily available. This is an opportunity for the teacher. The technology related to teaching/learning will have a vital role in the coming years in the education field.

We decided to use the EPUB3 format and the SIGIL platform.

EPUB is a format based on open specifications, primarily written in XML and XHTML. The EPUB format is supported by a wide range of devices and platforms, including Android devices, Nook, iPhone, iPad, iPod, MobiPocket, Adobe Digital Editions, FBReader, Stanza, Sony Reader, and many other readers and applications. The newest specification EPUB3 allows the creation of ebooks with sound, images and video. This specification introduces innovative features to address structure limitations, such as: precise layouts specialized for comic books, support for MathML, support for multimedia, and introduction of notes. In this way, the EPUB3 has the advantage that runs in both iOS and Android platforms and it is possible to make appealing layouts like those of the iBooks, which runs only in the iOS.

We choose Sigil because it runs in both Mac and Windows platforms, it is free and it has an intuitive interface, making it easy for teachers to create the eBooks for the students with the problems and video resolutions.

Figure 1 shows the layout of the cover and the index, which is generated automatically from the eBook content. This design while simple is effective since it is very easy to navigate in the eBook. The student can look form problems of a given chapter or look in the solution section for the video resolutions of those problems.

Figure 2 shows mathematic problems that the teacher prepared for students. These exercises are organized according to the math curriculum, in this case for the 10th grade, in chapters and sections.

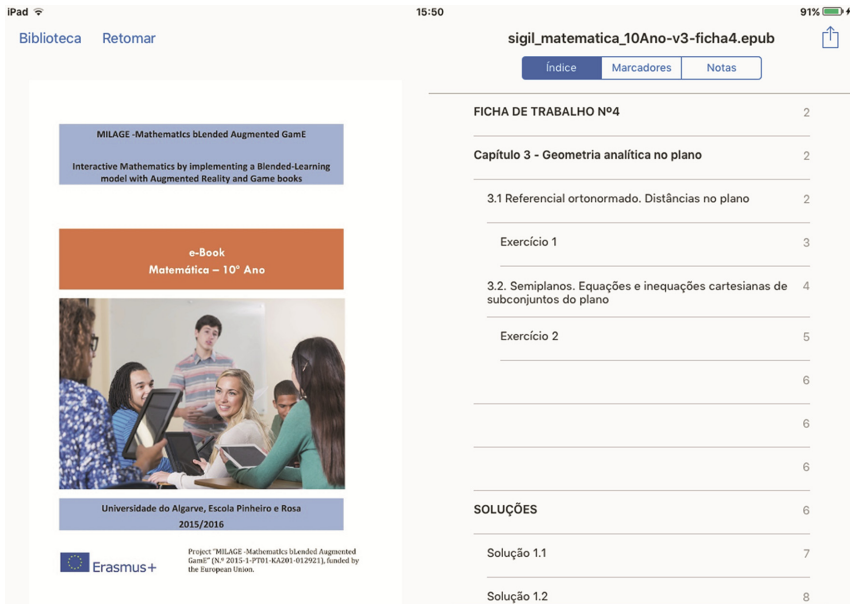


Fig. 1. eBook front page and index for the learning of mathematics

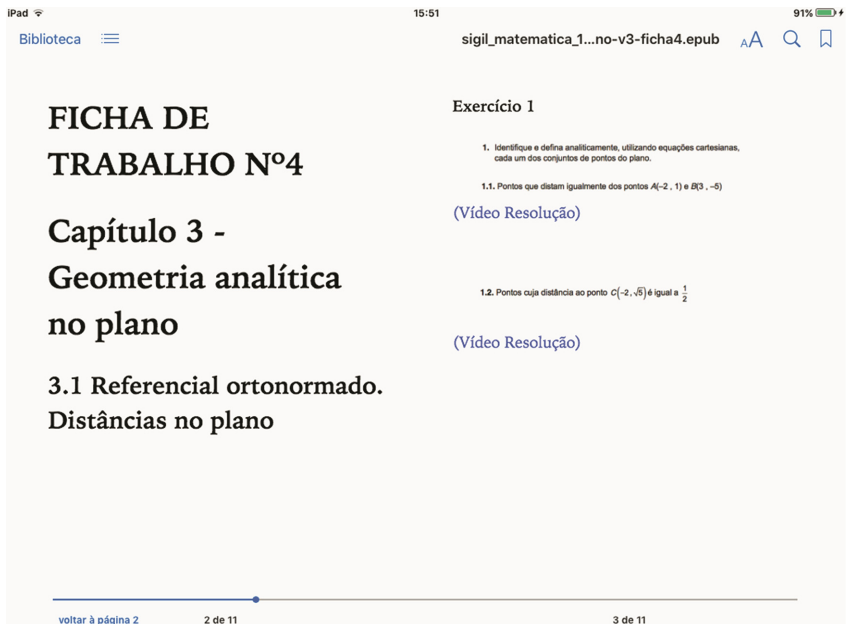


Fig. 2. Exercises are organized by chapters and sections in the eBook with video resolution of the mathematical problem

The use of videos for teaching and learning is effective for both visual and auditory learners as there is video and narration that is less complicated than written explanations [5]. Video recording is well suited for demonstrating basic concepts and problem solving. It allows students to learn at their own pace and in their own learning style. Video lectures are well adapted for classes with students who have different levels of knowledge of the subject. There are students that can view the materials once and have a good understanding of the subject. Other students can view the videos several times to better understand the subject. This is an advantage over the traditional classroom where many times the students do not understand and do not ask to repeat the subject until they are able to understand.

With the number of students increasing in the class this is an important tool to enable students to work at home and leave classroom time to implement problem based learning methodologies together with virtual learning classrooms.

Figure 3 shows the integration of the video resolutions of problems in the eBook. Students can see the videos after solving one problem using the link that is available together with the problem (Fig. 2) or going directly to the Solutions section from the Index (Fig. 1).



Fig. 3. Video resolutions of problems are available in the section *Solutions* of the eBook

In this way, students can easily navigate in the eBook and teachers can put together all the problems that they prepare for them.

## 5 Conclusions

In this paper we present the development of an interactive eBook to make available mathematic problems and the videos of their resolution, enabling the expansion of the classroom into a virtual space where students can have more time for practicing problem solving. This is possible because most students have a smartphone or a tablet and teachers should take advantage of these resources in the teaching and learning.

By using today's flexible, interactive and mobile technologies with the appropriate pedagogies, we believe it is possible to have students more motivated in maths, and expect a more creative response to the world problems that surround them. Moreover, information technology today has intuitive interfaces, is simple to use and is effective in the results. This is also an opportunity for teachers to produce content that is personalized and has high motivational impact on students. Producing an eBook with materials used and prepared by the teacher is one such opportunity. We also believe that technology is accessible and easy to use by math teachers and students, and much more can be improved with further work done in the field.

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