HOW TEACHERS BECOME CONTENT PRODUCERS: STUDENTS' USE OF EBOOKS

Mauro Figueiredo[1], José Bidarra[2], Rune Bostad[3]

[1] University of Algarve, ISE, CIMA, CIAC (PORTUGAL)
[2] Open University (UAb), CIAC (PORTUGAL)
[3] Nord University (NORWAY)

Abstract

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 several countries. 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. In this paper, we present the design and development of an ebook for STEM teaching and learning of mathematics. The teacher uses the template that we developed so that he can, in a user-friendly platform, write the ebook with the contents he designs for his students. In this way, the teacher has the possibility to include the problems that he finds suitable for the student. The teacher can produce and deliver the contents easily to students. 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. We also describe the workflow for developing this ebook. It was implemented 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. We describe the difficulties found in the integration of mathematics expressions in the MathML description in EPUB 3.

Keywords: ebooks, Mathematics, m-learning, EPUB.

1 INTRODUCTION

Theorists in educational technology point out that today's Net Generation, or Digital Natives, have become disengaged with traditional instruction. They require multiple streams of information, prefer inductive reasoning, want frequent and quick interactions with content, and have exceptional visual literacy skills.

On the other hand, the prominence of a robust STEM (Science, Technology, Engineering, and Mathematics) curriculum for the future of education in the 21st century is unquestioned. However, low achievement in mathematics education has been an increasing problem in recent years in many countries.

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 school education system would need to change, in order to accommodate students needs. According to the EU Commission initiative *Opening Up Education* [3], between 50% and 80% of students in EU countries never use digital textbooks, exercise software, podcasts, simulations or learning games. Most teachers at primary and

secondary level do not consider themselves as 'digitally confident' or able to teach digital skills effectively, and 70% would like more training in using ICTs.

Todays 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 [4], 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.

In this paper, we present the design and development of an ebook for 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. We have used the open EPUB3 specification to make a template for the ebook that teachers can use in the free Sigil application to produce an ebook for their students attending their specific needs. This will make it possible for a teacher to develop educational activities that can take advantage of mobile technologies for improving learning activities.

2   MOTIVATION

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. It's important to show students how technical notions relate to everyday situations and provide activities that help them apply known concepts in new contexts, thus promoting transfer of learning. In a study by NFER [5], exploring young people's views on science education, UK youngsters indicate that they would be more engaged with science if it were more applicable and relevant to contemporary life and transferable to 'real-world' situations. Furthermore, they expressed a preference for more practical, hands-on activities, when seen to be relevant to and integrated into the theoretical element of lessons, which they believed made learning science more interesting and subsequently easier to understand. This is achievable by fostering students' curiosity, supporting them during their personal and social meaning making processes and assisting them in developing creativity, problem solving and critical thinking skills.

In this regard, we find relevant the "21st Century Competences" put forward by Voogt & Pareja Roblin [6], covering major skills for success in our digital and networked world:

- Creativity – the ability to develop from scratch new solutions to emerging problems (communication, digital literacy);

- Critical thinking – the capacity to read, interpret, and evaluate new information (citizenship, communication, digital literacy;

- Problem solving – the ability to make decisions and implement the best solutions (communication, collaboration, digital literacy);

- Productivity – the ability to be more productive and apply higher-level skills (ICT competences are important here).

However, according to Anastopoulou et al. [7], evidence shows that young learners are not easily attracted to science as a school subject. Also, learners need to acquire the mental models that science investigation requires, but it is now widely acknowledged that the barrier to engagement goes further than a struggle with cognitive demands and constructs, such as 'control of variables' [8].

Recently, the European Commission [9] has launched a campaign to encourage girls aged 13-18 to study science, with the slogan "Science it's a girl thing!". This campaign tried to reverse the situation whereby girls tend to gravitate away from science, math and technology studies. Moreover, according to a recent study on the changing pedagogical landscape [10] 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 [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.

We argue that, to profit from the opportunities that the seamless learning spaces of today offer [11], we need an innovative perspective for the instructional design of science and math education supported by an operational model of activities. We noticed that almost every model has its activities based on a specific context, on a set of technologies, and on clear pedagogical concepts. However, only in a limited number of cases the affordances of current technologies (e.g. mobile, AR, VR) are taken into account to create motivating activities for both male and female students, in authentic settings, and adapted to science learning requirements.

So, in this paper we present an ebook that is set for improving mathematical performance and achievements for all students, including also low achievers and 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 to 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

This section presents several authoring tools that can be used for the writing of an ebook.

At the most basic level, the ebook is an electronic book that can have a simple format, such as a text in PDF. However, there are currently more advanced standards, such as EPUB3 (universal) or iBooks 2 (Apple), that can integrate multimedia components. Ideally, an ebook should have sufficient quality for current devices with their high-resolution displays, and be compatible with a wide variety of reader apps, and if necessary allowing the conversion to other formats. In actuality, however, there are more than a dozen formats not compatible with each other, and sometimes they do not adapt to higher resolution screens.

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. Of the most popular devices, the only one that does not support EPUB is the first Amazon Kindle. The EPUB specification is an open standard, allowing the creation of

ebooks with sound, images and video (in its newest specification - EPUB3). 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.

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 [12]. 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 export them into EPUB3 documents. Ebooks created with Sigil may contain text, pictures and links, vide 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. To write MathML it is necessary to use the code view mode. Sigil also have the capabilities to write own clips of code that makes it easy to insert into the document with just click on button you have assigned to the clip. To get full utilization of Sigil a knowledge of HTML and CSS is needed.

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.

oXygen is a XML editor which have support for EPUB2 and EPUB3 standard. It has predefined templates for EPUB2 and EPUB3 that can be used when creating a new ebook, or it is possible to open an existing file and start editing. The program is written in Java and is available for Windows,

Mac OS X, Linux and it can even run as a plugin in Eclipse. It provides multiple views of the document. In Text mode it will show the html code, in Grid mode it will show which html tags are enclosed within other html tags and the last mode is Author mode where it has WYSIWYG capabilities. In Author mode, it is possible to edit the content directly and oxygen will place the html code for you. oXygen also have possibility to edit MathML in a fragment editor, but you have to write the MathML yourself and you will see how it looks in a preview window. If you want a MathML editor, it is possible to install MathFlow editor but a license is needed. To use oXygen, knowledge of HTML and CSS is needed. It is not free or open application, so it will require a license.

Pages is a text editor from Apple, where you can write like using word. Pages are only available on Mac OS X operating systems. It has capabilities to export to EPUB. It will convert images and videos in documents to proper format, so it will support the EPUB standard. To create a new EPUB it is possible to choice an existing template and it will set up stylesheets for the book. Different from EPUB books created with iBooks Author tool are that EPUB books created with Pages can be read at any device/reader that support the EPUB standard. It is easy to use and it is not necessary to have any knowledge about HTML and CSS. It does not support MathML.

We decided to use the EPUB3 format and the SIGIL platform. The EPUB3 allows teachers the writing of ebooks that can include videos with the resolution of mathematical problems and tasks, which are well suited for teaching. This specification also support for MathML, which is very useful for us. It has the advantage that it is free and 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.

4   DESIGN AND DEVELOPMENT OF AN EBOOK FOR MATH TEACHING

In the MILAGE project we want to give to the teacher the possibility to write for the students the ebook of their classroom. Teachers are making mathematical activities including problems and tasks for students, which are prepared taking in account the class, the level of the students to include both the low and top achievers students. The technology is accessible and there are available free tools that let teachers produce their own contents and make it available to students promoting a personalized learning environment.

Teachers are writing their ebooks using the free and open standard EPUB 3 that is available for Android and iOS platforms. This specification supports video embedded in the ebook. This is an important new feature that teachers are using to make videos available about lectures and problems resolutions, which is especially interesting for learning mathematics.

Students can solve and visualize video lectures and do home works outside the classroom. The traditional classroom can be extended into a virtual class, where students can learn at home from watching video lectures and solving problems. Time in the classroom 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 choosed the Sigil platform that runs in both Mac and Windows operating systems, 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.

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

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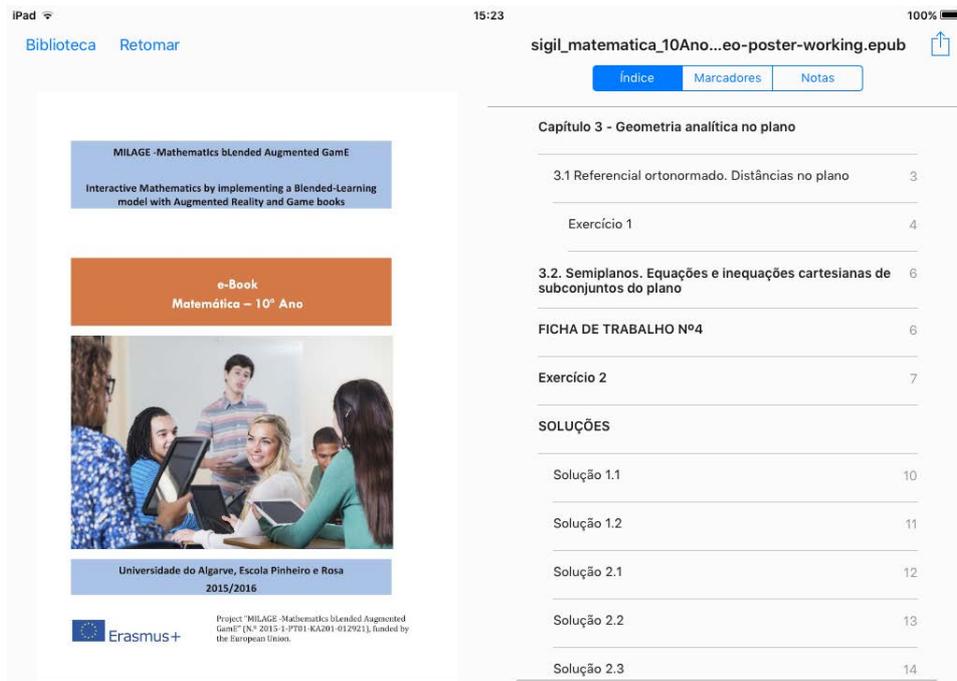
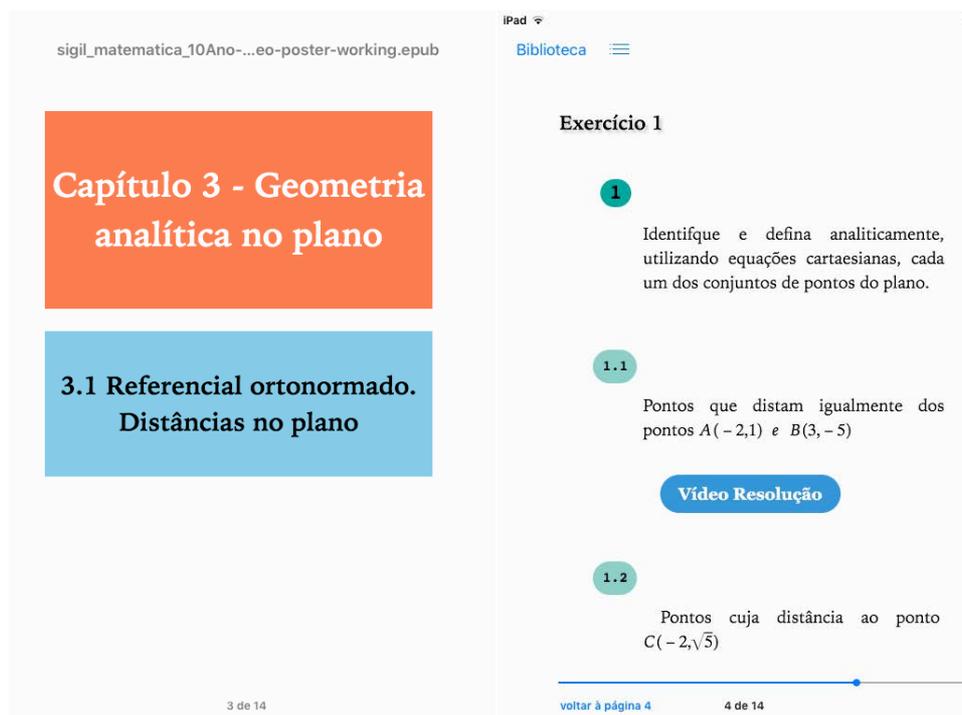Fig. 1. Ebook front page and index for the learning of mathematics.

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

To create a CSS that is working on both platforms (iOS and Android) and on different devices can be cumbersome. We wanted the layout to have some colors, some features like buttons to have rounded corners, exercise numbers to rounded corners on with a color filling etc. For example to get the rounded corners it was not enough just to have *border-radius* property in the CSS, since it wouldn't show correctly on every devices of both platforms that we tested. So to correct it and show it correctly on every devices we had to add the property *–webkit-border-radius* along with *border-radius*. This happens because platforms are using different engine to render the layout. Another solution would

have been creating different CSS for each platform (iOS and Android), and the teacher had to create two ebooks, and let the pupils choose which version of the ebook wanted.

We also developed a template that is shared and used with the different teachers of the project. The CSS for the ebook was constructed to use normal tags, like h1, h2, h3, a etc so the teachers can use the buttons that Sigil already have when they are constructing the ebook. In this way, teachers do not need to know CSS programming, since they use the template that we developed. For special things like adding an exercise number, it is possible in Sigil to add what they call clips. This means that teachers will have these clips like buttons, and teachers only have to click on the clip/button to add the layout they want. These clips are saved in a file that make it possible to copy and paste the clip-file, so the teachers do not have to setup this for themselves.

Another problem was the MathML. We did not want teachers to write MathML in notepad, directly into the code, but rather that they will have a free software with WYSIWYG functionality. After trying different solutions we came up with Libreoffice Math that gave us a clean MathML code that could be inserted into the ebook. The more inconvenient part is that the teacher has to change from book view in Sigil to code view and insert the MathML code there. But, the main thing, which is important for us, is that Libreoffice Math is creating a clean MathML code that works on both platforms and different devices. With other software it often didn't work on both platforms and different devices since the software was introducing different prefixes which the different MathML renderer engine on the devices interpreted differently or didn't interpreted at all.

To test the ebook template developed we used Gitden Reader on Android devices and iBooks/Gitden Reader on iOS devices. The reason we choice Gitden Reader is that it is available on both platforms and it is a free app, without ads.

With the developed template teachers could create the ebook for their students. In this way, students can study mathematics from the exercises produced by the teacher and they can watch the videos with the resolutions of exercises.

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 [14]. 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.

Fig.3 shows the integration of the videos of math problems' resolutions 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). In this way, students can easily navigate in the ebook and teachers can put together all the math problems that they prepare for them.
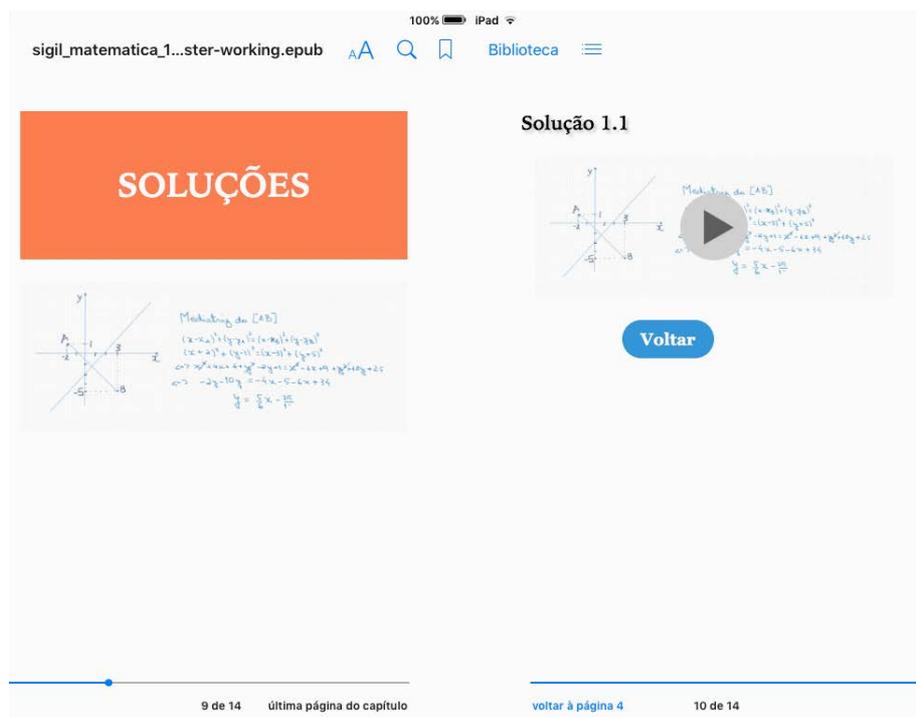
Fig. 3. Videos with math problems' resolutions are available in the section Solutions of the ebook.

5 CONCLUSIONS

This paper presents the development of an ebook that uses the latest EPUB3 specification that teachers use to show mathematic problems and the videos of their resolution to students. This gives an unique opportunity for teachers to provide contents according to the classroom needs and enables 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.

This paper also shows the difficulties found in the use of the ebook authoring tool for this research and the integration of mathematic expressions in the MathML for EPUB3.

The ebook is a great tool for students that is available through mobile devices. 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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