Developing Tools for the e-Learning Platform MathE

Ana I. Pereira¹, Florbela P. Fernandes², M. Fátima Pacheco³, Paula M. Barros⁴, Flora Silva⁵, Edite Cordeiro⁶, Carla A. S. Geraldes⁷, Clara B. Vaz⁸, Elisa Barros⁹, Inês Barbedo¹⁰, João P. Almeida¹¹, Cristina Martins¹², Manuel V. Pires¹³

Research Centre in Digitalization and Intelligent Robotics (CeDRI), Instituto Politécnico de Bragança, Campus de Santa Apolónia, Bragança, Portugal^{1,2,3,7,8,11}

Instituto Politécnico de Bragança, Campus de Santa Apolónia, Bragança, Portugal^{4,5,6,9,10}

Centro de Investigação em Educação Básica (CIEB), Instituto Politécnico de Bragança, Campus de Santa Apolónia, Bragança, Portugal 12,13

Abstract

MathE (mathe.pixel-online.org) is an e-learning platform for higher education developed and implemented by a consortium of seven institutional partners from five European countries. The aim of the project is to enhance the quality of teaching and improve pedagogies and assessment methods by facilitating the identification of students' gaps in Math, providing appropriate digital tools and promoting self-evaluation with immediate feedback. The Polytechnic Institute of Bragança (IPB), in Portugal, is one of the consortium members: sixteen of its teachers collaborate in the development of this platform, being responsible for thirteen of the topics/subtopics in which the platform is structured. Such topics cover a wide range of contents, from linear transformations to integration, from graph theory to probabilities. The articulation of the topics of the MathE collection corresponds to the canonic mathematics content of engineering, business and education degrees. The MathE platform is organized into three main sections: Student's Assessment, MathE Library and Community of Practice. So far, IPB has already developed a collection of around 800 questions for the student's assessment section and is currently developing the MathE Library. More than 350 students from IPB are using the MathE platform: some offered as volunteers, whose role is testing the behavior of the platform as well as looking for bugs and other details that require improvement, while others are already using the platform in their study. The feedback received up until now is quite encouraging.

Keywords: Active learning. Higher education. Pedagogical innovation. Digital resources. Distance learning. Mathematics.

1. Introduction

The teaching and learning process has progressed from a paradigm relying on expositive teaching to a paradigm centred on active teaching and on the definition of new roles both for teachers and students [1, 2]. The rise of new technologies has contributed to and promoted such change, enabling new forms of representation, self-expression and collaboration in knowledge [2]. E-learning is a concept arising from the usage of information and communication technologies to revise and transform traditional models of teaching and learning [3]. According to [4], e-learning constitutes a broad approach that brings new opportunities for learning and teaching outside the traditional classroom environment. Considering the views of [5], in the teaching and learning process, technological mediation - digital and online - stands as the fundamental identity element of e-learning. It is based on this attribute and its combination with others — distance, interaction with a tutor and/or existence of a trainer — that the concept of e-learning is built. According to the mentioned authors, elearning as a teaching method is far from constituting a stable and consensual subject regarding theories and practices. If technologies move forward at a speedy pace, pedagogical models, on the other hand, resist and change slowly and in an uneven rhythm. Hence the need to build an open device in constant evolution, ensuring its validity and conformity to the evolutions of the organizations and people.

Bezovski and Poorani [6] claim that if, at first, most concerns regarding the e-learning process focused on supporting technologies, they are now centred on the usefulness of platforms and tools and on pedagogical considerations. Regarding e-learning tools, many support synchronous and asynchronous learning such as videoconferencing, virtual classrooms, webinars, presentations, videos, audios, graphics, texts, wikis, blogs, chat-rooms and so on. As far as research is concerned,



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they remark that e-learning trends include, among others, combined learning, gamification, MOOCs, Software as a Service (cloud learning), personalized learning and continuous learning [7 - 13].

The MathE platform is a digital tool (https://mathe.pixel-online.org), that involves the collaboration of several European institutions from five different countries, such as the Polytechnic Institute of Bragança (Portugal), the Limerick Institute of Technology (Italy), the University of Genova, Pixel (Italy), Kaunas University of Technology (Lithuania), Technical University of Iasi (Romania) and EuroED (Romania). Each of the partner institutions has built a solid community of teachers, in the corresponding countries, that have been actively collaborating and responding to the challenges of the project.

The main goal of the MathE project is to develop proficiency in the teaching of mathematics in higher education (although some themes cover high-school contents and can be used at this level); MathE involves teachers and their students, as well as external participants who want to deepen their knowledge of mathematics. Students have access to pedagogical resources such as videos, classes, exercises, training tests with multiple choice questions and other formats, that are freely available in the MathE library, an online database of teaching/learning resources. Teachers can make their classes less orthodox and increasingly rely on the online resources that MathE offers.

The MathE project is already making a significant contribution to innovation in higher education, by developing and implementing the described new approaches for teaching and learning mathematical concepts. The use of the resources produced within the project and, therefore, the introduction of unconventional pedagogical practices in the scientific area of mathematics can be a valuable asset in the current transition from face-to-face to distance learning and to the introduction of b-learning formats that the current COVID19 scenario forces institutions to.

This paper is organized as follows. After the introduction section, the contributions and the way MathE operates will be presented in Section 2. Some observations about feedback from users will be provided in Section 3 as well as a brief explanation about the community of practice, in Section 4. Conclusions and possible directions for future work will be included in the final section.

2. MathE Developing and Contributions

The MathE platform is currently used by a group of more than 500 students (350 from IPB) and 50 teachers (16 from IPB), from ten countries. It is an open digital education tool that combines dynamic exams for self and final assessment, a library (with video lessons or other video resources and teaching materials - such as presentations, graphs, notes and books) and a community of practice. Therefore, the MathE platform relies on unorthodox types of resources and strategies to promote the students' interactivity, avoiding monotony and enhancing the effectiveness of the student's learning process and the student's learning experience. The variety of resources available within the MathE platform contributes to make the students' more autonomous, allowing them to organize their study at their own pace.

From the students' point of view, the MathE platform works as a repository of videos, written material that help them learn and online dynamical exams that allow them to test their knowledge, thus increasing engagement, motivation and sense of challenge as well as awareness of each one's situation regarding the considered course. The dynamical exams are randomly elaborated from a database of questions organized under topics and subtopics; each exam has seven questions randomly generated from the content of the database, considering a selected topic/subtopic.

From the teacher's perspective, MathE project promotes the use of digital educational tools and offers resources for the evaluation of the progress of the students' knowledge as well as discussion among teachers and researchers about good practices in math teaching, therefore increasing engagement and motivation.

At the moment, the platform covers 14 domains of mathematics, some of which are organized into subtopics, namely: Analytic Geometry, Complex Numbers, Differential Equations, Differentiation (2 subtopics), Fundamental Mathematics (2 subtopics), Graph Theory, Integration (2 subtopics), Linear Algebra (5 subtopics), Optimization (2 subtopics), Probability, Real Functions of a Single Variable (2 subtopics), Real Functions of Several Variables and Statistics. MathE offers 24 subtopics/topics and the IPB research team is responsible for the development of all the features related with 13 subtopics/topics. The assessment section is already implemented, having almost 800 questions. At this moment, the IPB team is developing the video lessons and the teaching resources for the library section.

Taking into account the structure of the MathE platform, it can be integrated in a course curriculum supporting lectures or helping the students maintain a continuous and regular learning effort



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throughout the semester. During the semester, the final assessment area can support the teachers in the elaboration of their own exams on the topics they wish to evaluate.

One of the most important features in the MathE platform is its video collection, with linkage to carefully selected videos available on the Internet. The selected videos are either produced by the project team members (among the several partners of the consortium) or they are previously existing videos, publicly made available by a third party. The key common factor among all videos in the platform is their ability to help students and teachers to focus on particular aspects of the covered subjects.

For a student, the video library represents a handy tool, permanently available, to get that enlightening spark that allows one to pass from doubt and confusion to consistent knowledge about a specific math topic. For the teacher that worries about the student's performance, the MathE video library offers a way to help consolidating knowledge, especially in what regards overcoming the difficulties about basic mathematical facts, together with mastering the skills on each of the topics covered by the project. Hence, the teacher can elaborate specific - even individual - programs for the students and help them improve their performance.

Both teachers and students can update this open digital tool, through the inclusion of new problems and resources, turning the MathE platform into a collaborative educational tool. All submitted materials are previously validated by elements of the MathE consortium.

3. Feedback from Users

By providing a considerable list of exercises on several topics, offering the student access to short videos and other online communication tools on the covered subjects, the MathE platform presents itself as a tool adjustable to classroom environment, to assess and learn the concepts under study, in a flipped classroom operating logic. According to the feedback provided by teachers, about the experiences already carried out in their classroom, the MathE platform arises as a good option to practice and review specific mathematical subjects. It has been noticed that the work proposals mediated by this platform increase the students' involvement. The random generation of sets of questions determines that students work with different questionnaires, which requires greater autonomy. Submission of the questionnaire gives access to the results and, whenever an answer is wrong, the platform indicates the correct option and suggests a short video lesson or another source to clarify the issue. This makes it possible to overcome difficulties and understand the concepts and, in this process, students tend to question the teacher more often than in traditional classes.

In the classroom, the teacher may also choose to encourage collaborative work, through the proposal of group activities mediated by the MathE platform. Online questionnaires on already covered topics are regarded by students as challenges that they try to overcome and, for that reason, they become more involved and tend to develop skills of self-learning and conceptual understanding of the subjects. With this dynamic of group work, conversations with colleagues tend to be less oblivious to classroom issues.

The use of MathE Library (video collection and teaching material) to explore new subjects is also a possibility. It is intended that the collection of material and short video classes, still under development, will be an asset for the presentation and investigation of many of the main mathematical topics in higher education. Moreover, note that the teacher can also use this functionality to carry out the effective assessment of topics already taught.

Outside the classroom, MathE platform can play a key role in motivating both students and teachers to learn and improve their skills in the several mathematics topics.

With the MathE platform, teachers can implement a specific program especially designed for their students. This will help teachers to foster their students to evolve from simple to more complex knowledge in their disciplines. This is achieved through the careful selection of questions from basic to a more complex degree of difficulty (these degrees are identified in every question). The student can enrol the program with autonomy and its own velocity.

On the other hand, MathE platform can stand as precious tool for self-learning. In fact, student's can take their own tour through the many topics covered, from the most important mathematical areas. The videos linked from the questions will help the students to get the necessary insights of the subjects and the assessment tool will help students to confirm the level of knowledge they have achieved.

4. MathE Community of Practice

Young people often regard mathematics as an extremely difficult discipline, dealing with objects that are strongly abstract and more or less incomprehensible. The community of practice forum gives voice



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to the students' questions and fears. In this forum, teachers and students will have an opportunity to discuss strategies to solve problems or to share interesting situations that arise in their practice. Conversations between students can be promoted with or without the intervention of teachers: in solving the exercises, challenges or in joint reflection about the obtained answers, debate can be launched.

Moreover, within the scope of MathE, an online guide to best practices in mathematics education will also be produced. Such guide will promote the exchange of learning experiences between teachers and researchers, as well as an increase in the internationalization, mobility and cooperation of teachers from different institutions and backgrounds.

5. Conclusion and Future Work

In an era when the Internet, the large amount of available digital resources and technological devices - and also the recent developments related to the COVID19 pandemic - are forcing all levels of the teaching system to reinvent themselves, it becomes necessary and urgent to implement different strategies in teaching and learning processes for all levels and areas, namely in what concerns Mathematics. The MathE platform is an online tool that comprises three main sections – assessment, library and community of practice – and can be used by students and teachers in order to motivate them to better learn and improve their skills.

Teachers and students from several countries are already relying on this tool; nevertheless the users' community is still growing.

The IPB researchers developed around 800 questions for training and assessment, organized into 13 topics/subtopics. Videos linked to Internet sites are already available. The execution of video classes is currently being carried on.

Until the moment the feedback received from the teachers and the students is encouraging. Teachers state that the MathE platform allows students to be more independent and proactive; their behaviour is reshaped and they are more engaged in the relationship with mathematical subjects.

Students' feedback indicates benefits taken from the possibility to elaborate one's own path throughout the topics available in the MathE platform.

As future work, the increase of questions' database as well as the number of topics of MathE portal is planned.

Acknowledgements

This work is supported by MathE - Improve Math Skills in Higher Education financed by Erasmus+ Programme's Strategic Partnerships No. 2018-1-PT01-KA203-047361 and by FCT – Fundação para a Ciência e Tecnologia within the Project Scope UIDB/05757/2020.

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