ReM@t – a Project to Help Students to Improve Mathematical Skills

Tatiana Salvador, Sandra Pedrosa, Inês Messias,
António José Mendes, Jaime Carvalho e Silva

Abstract: *This paper presents the "ReM@t - Recovering Mathematic at a distance" project. It includes the implementation of a free open course, designed to help students to improve their mathematical skills, namely those that they are expected to master when in higher education. The lack of mathematical knowledge is often mentioned as a problem for students that start courses in fields such as Engineering, Economics and Management. So ReM@t aims to improve success rates in those courses. This paper presents the project, the course and an evaluation experiment conducted in its first development stage.*

Key words: *Distance Education; e-Learning; Math; Diversified Public.*

INTRODUCTION

A number of reports suggest that first year engineering students "are not well prepared to deal with the mathematical content of their courses" [3]. Researchers have discussed extensively the matter and agree that students are "entering university with insufficient mathematics preparation for the courses they intend to study" [5]. This problem exists in various degrees in all countries and has been the goal of numerous actions (like remedial courses or bridging courses). Mathematics is essential in any higher education course in the fields of Science, Engineering, Economics and Management. The STEM areas (acronym for Science, Technology, Engineering and Mathematics) are very important and some strategies have been proposed to improve them in the European Union [2]. In this report, it is considered essential to increase students' performance and interest in pursuing studies related to STEM areas.

As technology evolves, more and more tools are easily available and become more powerful. So it seems natural that bringing together digital tools such as GeoGebra[17], animations, videos and online tests to a math course may lead to some gains. Most international reports show that there are advantages in the use of carefully designed technological environments to teach and learn mathematics [1].

This paper presents how the maths course developed within the ReM@t Project. It uses a completely new approach to math teaching in Portugal. It aims to reach pre-university and first year students through a free online course, available at any moment to any student that wishes to improve mathematical knowledge and skills. The course combines technology with novel approaches to mathematical concepts, to better prepare young students to succeed in their higher education programs.

INSTRUCIONAL DESIGN OF THE COURSE

The ReM@t course development used the instructional design, development and implementation processes used in UC_D, the University of Coimbra distance learning project (see figure 1).

17 GeoGebra software, created by Markus Hohenwarter, is a free dynamics Mathematic software, accessible at: https://www.geogebra.org/

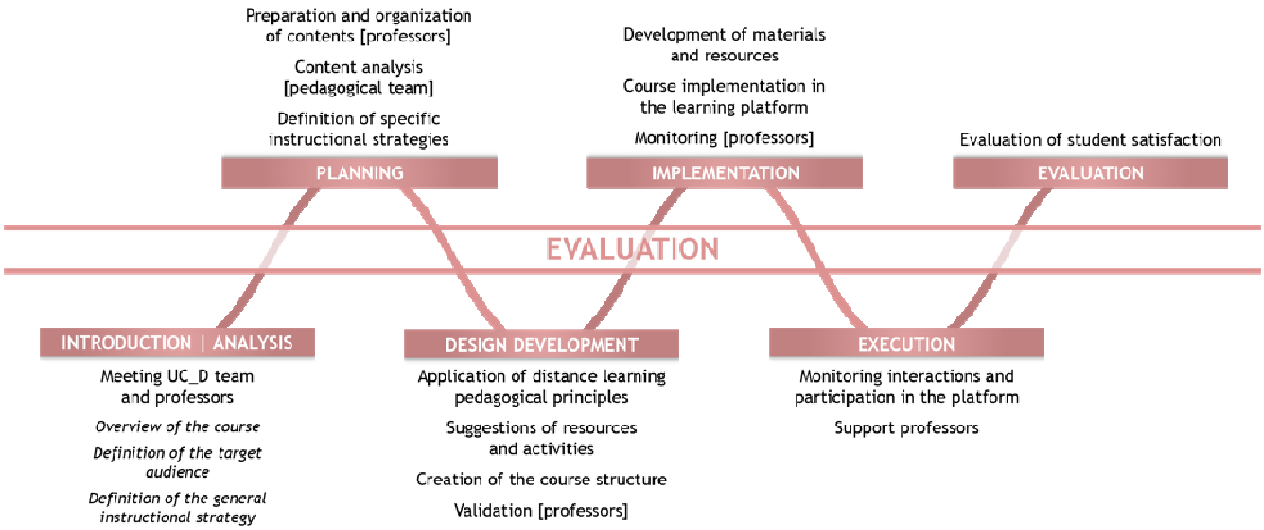

Figure 1. Instructional process used at University of Coimbra Distance Learning Project (Pedrosa et al., 2011, p.152)

This process demands knowledge in the scientific fields of the course, and technical knowledge concerning the usage of the appropriate technological resources. In this particular case we involved specialists in mathematics didactics, but also in pedagogy, multimedia and design.

The course is supported by the Moodle used in the University of Coimbra Distance Learning Project. Students have, in this platform, access to a set of communication tools (forums, message) that may support their learning process. In particular, forums are seen as collaborative learning tools, where learners can share experiences, ask questions and become engaged in building a learning and practice community.

The ReM@t project included three main stages:

Stage 1: Identification of student's more common mathematics difficulties when they reach higher education. The main objective was to define which modules should be developed in the project context. This study considered what can be found in literature, but mostly the vast experience in introductory maths courses of some teachers involved in the project. From this work three modules were identified as the most necessary: Functions and Graphics, Powers and Exponentials and How to Study Mathematics. The last one seems particularly important, as we believe that many students don't use the best study strategies to be successful in maths learning.

Stage 2: Development of the course. The main pedagogical decisions were made at this stage. Knowing the modules to develop, it was necessary to define adequate strategies to support student's learning. The contents, activities and resources to use were planned and implemented at this stage. The general graphical image of the course was also defined. After a careful planning all materials were created and inserted in the platform.

Stage 3: Evaluation. It is necessary to evaluate if the course reaches its objectives when used by real students. So, pedagogical and usability tests need to be done, and its results used to improve the course. A first iteration activity already took place.

COURSE DESCRIPTION

The course is organized in modules that are segmented into chapters, where contents is presented in various formats - text, images, interactive diagrams, videos and interactive graphics (created in GeoGebra). There are also practical exercises that enable students to measure their learning. The use of different formats tries to address the different learning preferences that probably will exist among the course students.

The course modules are independent, allowing students to decide which module(s) they need to follow and by which order. Additionally, it is also possible for students to manage their availability and time, as there are no time restrictions to completing the tasks, exercises or modules. Moreover they can consult a timetable that works as a guideline to help students to better organize their study.

Contents, applets, videos and other resources available in the course were designed to help students to better understand the contents and their connections. The students can also solve several exercises proposed after each topic. The idea is to allow them to test if they have understood the topic correctly. Moreover, when students cannot solve an exercise a hint is automatically given, trying to help them to reach a correct solution. If the student solution still remains incorrect the correct answer is presented.

All modules have a similar structure and organization. Furthermore, the tools and resources used are also similar. With this we aim to reduce the adaptation students need to make use of the course strategies and contents.

To allow a better understanding about the course, we will describe in more detail the contents of module 1 - Functions and Graphics - with examples of some resources used.

Module 1 includes several topics related to the graphical representation of functions: dependent and independent variable; abscissa and oriented real line; ordinated abscissa and representation of a point on a plane; definition of function, properties and underlying definitions; and how to build graphics from functions' expressions and vice versa.

The interactive graphics presented in the course help students to understand the behaviour of a specific function, by allowing them to modify one or more variables and see the result. Figure 1 shows an example about functions of type f(x)=kx. The idea is to show how the variation of k affects the function representation. The student can choose any positive value for k (within the allowed range) simply using the slider in the top left side of the image. The function graphic automatically adapts to the new k. Through this exercise it is also expected that students understand that functions of this type are always increasing when k is positive.

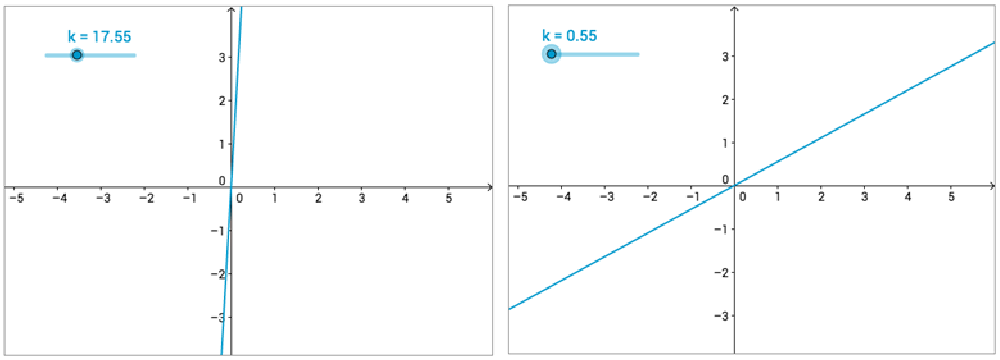

Figure 2. Example of an interactive graphic used in the course, designed used GeoGebra software

Animated diagrams can give a more interactive and dynamic vision of the course and make mathematical learning more motivating and appealing. Figure 2 illustrates an animation that explains the construction of the abscissa and the representation of some integer numbers on that axis.

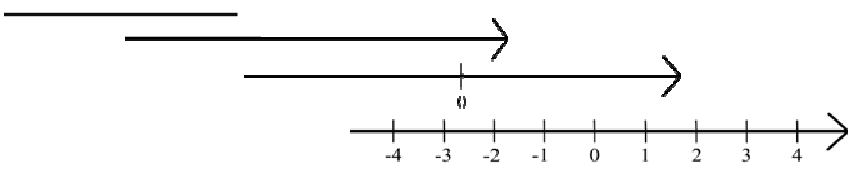

Figure 3. Sequence of images from one of the course's animated diagrams

The illustrative videos are mostly based on common situations and iconic symbols from Coimbra city. The idea is also to help students to understand important mathematical concepts. Figure 3 shows two images from one of the course's videos. They represent iconic symbols of Coimbra's city, specifically, the Monastery of Santa Clara-a-Velha and Santa Clara Bridge. With this video we aim to clarify the concepts of constant and variable, making an analogy between the (constant) geographic location of the Monastery and the (variable) number of cars passing in the nearby bridge.

Figure 4. Example images from one of the course's videos

The first course evaluation involved students from the foundation year of the course of Science and Technology at the University of Coimbra. It is a course that aims to prepare students to enter higher education. So, it seemed to be an adequate environment to test the first module of the course, Functions and Graphics. Most students that follow this course show deep difficulties in mathematics. This experiment took place between February and April of this year, and it is detailed in [6].

Our main goal with this first experiment was to see where and how we can improve the course. To do that, we (i) observed and noted the reactions and behaviours of the participants in order to verify if the contents and its presentation were adequate; (ii) payed attention to the difficulties the students showed while accessing the platform, (iii) observed their perception of the organization of the course, of the use of the available tools (interactive elements, videos, applets, animated gifs, etc.) and also the difficulties presented in the perception of content.

The results of this first iteration were very positive. They allowed us to understand that the course helped several students to clarify various mathematical concepts and motivated many of them to work to overcome their learning difficulties. With this first iteration, it was possible to observe the student's engagement while attending the course, allowing us to conclude that the use of the interactive tools and the benefit from the practical day-to-day examples they need to have a basic understanding of the contents, may also motivate them to know more and learn more. It was possible to conclude that to use the interactive tools and benefit from the practical day-to-day examples they need to have a basic understanding of the contents. It was also possible to conclude most students found the course useful as complementary and alternative approaches to their previous learning experiences.

Taking into account the results from this experiment we will pursue this path in order to make the course more and more interactive, motivating and efficient. Although this experiment's conclusions were clear about the path we should continue to follow, we consider that other experiments will be necessary so that we can improve the course and satisfy the needs of the diversified publics to which this course is intended to cater.

CONCLUSIONS AND FUTURE WORK

The first iteration was important because it reinforced the idea that students' mathematical difficulties can be addressed with the help of an e-learning course that encourages independent and peer to peer learning, fostering the consolidation of prior

knowledge. Furthermore, it proved that the use of interesting, simple and appealing study tools can, in fact, be an added value to the understanding of mathematical contents.

In the future we will keep improving and enlarging the course with more modules, so that students can better understand mathematical concepts that are important in the transition from secondary to higher education. It is also our intention to make new studies, in order to better understand the target audience needs and ways of improving the course.

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ABOUT THE AUTHORS

Researcher. Tatiana Salvador, Master, Distance Learning Project, University of Coimbra, Phone: +351 239 242 717, E-mail: tatiana.salvador@uc.pt

Researcher. Sandra Pedrosa, Master, Distance Learning Project, University of Coimbra, Phone: +351 239 242 717, E-mail: sandra.pedrosa@uc.pt

Researcher. Inês Messias, Master, Distance Learning Project, University of Coimbra, Phone: +351 239 242 717, E-mail: ines.messias@uc.pt

Assoc.Prof. António José Mendes, PhD, Department of Informatics Engineering, University of Coimbra, Phone: +351 239 790036, E-mail: toze@dei.uc.pt

Assoc.Prof. Jaime Carvalho e Silva, PhD, Department of Mathematics, University of Coimbra, Phone: +351 239 791 150, E-mail: jaimecs@mat.uc.pt

The paper has been reviewed.