INTERACTIVE LEARNING MATERIALS CONTRIBUTION FOR STUDENTS' ENGAGEMENT IN E-LEARNING OF MATHEMATICS CONTENTS: A CASE STUDY DURING THE COVID-19 PANDEMIC

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Abstract

The purpose of this paper is to investigate the impact of the use of interactive e-learning materials for students' engagement in a Mathematics course, concerning the shift from face-to-face classes to online and virtual learning systems, during the COVID-19 outbreak and the lockdown in one of the schools of the Porto Polytechnic.

On March 16, 2020, Portuguese Government ordered the closure of all educational institutions, due to the ongoing outbreak of coronavirus disease (COVID-19). Faced with this problem, since students and educators could not be physically present in a traditional classroom environment, two alternatives were "on the table": suspending courses to reopen them later, when the pandemic "ended", creating major disruptions in traditional educational calendars, or developing new strategies for the courses to continue, trying to maintain almost all planned educational activities through the use of information and communication technologies, in a distance teaching/learning basis. Our Institution, after analyzing the pros and cons, decided to choose the second alternative. So, in such a short time and without any kind of groundwork or anticipated planning, our traditional ways of learning and teaching were drastically changed. With no further notice, teachers were compelled to adopt remote teaching strategies and to develop synchronous and asynchronous courses. Therefore, using all kind of distance learning strategies, students have been able to continue with their studies, concluding the academic year without ever returning to on-site teaching. However, the efforts did not come without problems: slow or even no Internet connections, no or inadequate devices or technical support, lack of digital proficiency from all educational actors are just some of the challenges faced. On a positive side, extraordinary opportunities must be recognized in the form of innovations and digitalization of the current practices. The opinions of the participants of the study will help demonstrate what may be considered as best practices and problem solving through the use of interactive e-learning materials in times of crisis.

Keywords: Innovation, Technology, Interactive Learning Materials, Higher Education, Online Learning, Distance Learning, COVID-19.

1 INTRODUCTION

Coronavirus disease (COVID-19) emerged in Wuhan, China, at the end of 2019 [1]. COVID-19 is an acute, sometimes severe, respiratory illness caused by a novel coronavirus SARS-CoV-2. The clinical spectrum of SARS-CoV-2 infection appears to be wide, encompassing asymptomatic infection, mild upper respiratory tract illness, and severe viral pneumonia with respiratory failure and even death, with many patients being hospitalised with pneumonia in Wuhan and it soon became clear that efficient person-to-person transmission was occurring ([2], [3]). In a short period of months, the disease went beyond the boundaries of China and spread quickly to other countries worldwide. On March 11, World Health organization (WHO) declared COVID 19 a global pandemic, having been reported to WHO, up to 8 January 2021, 86 436 449 confirmed cases of COVID-19, including 1 884 341 deaths [4].

Most governments around the world have temporarily closed educational institutions in an attempt to contain the spread of the COVID-19 pandemic. The United Nations Educational, Scientific and Cultural Organization (UNESCO) estimates that nearly 172 countries have closed educational institutions nationwide, and several have implemented regional or local closures [5].

On March 16, 2020, Portuguese Government ordered the closure of all educational institutions, due to the ongoing outbreak of COVID-19, just few days after the first confirmed case in Portugal in the 2nd of March and just two days before the complete country "shutdown", since on the 18th the state of emergency was declared by the President of the Republic, based on the confirmation of a public calamity situation [6].

With the pandemic limiting our ability to move around, the government imposing lockdown and social distancing measures to curb the widespread of COVID-19, has led to an exponential increase in the use of online learning methods in the educational system. So, in less than two weeks all Portuguese High Educational system was “upside down”, with all its actors confined to their respective home residences. Faced with this problem, since students and educators could not be physically present in a traditional classroom environment, two alternatives were “on the table”: suspending courses to reopen them later, when the pandemic “ended”, creating major disruptions in traditional educational calendars, or developing new strategies for the courses to continue, trying to maintain almost all planned educational activities through the use of information and communication technologies, in a distance teaching/learning basis.

Our Institution, who had declared, on March 11, the temporary suspension of teaching activities between March 12 and 27 [7], after analyzing the pros and cons, decided to choose the second alternative on March 25, establishing the “Teaching Rules” in a general document, for all Porto Polytechnic (P.PORTO) Schools [8]. Hence, in such a short time and without any kind of groundwork or anticipated planning, our traditional ways of learning and teaching were drastically changed. Teaching was moving online, on an enormous and untested scale. With no further notice, teachers were compelled to adopt remote teaching strategies and were able to continue to deliver learning online via technological tools and trying maintain quality education. Therefore, using all kind of distance learning strategies, students have been able to continue with their studies, throughout the state of emergency period (that ended on the 2nd of May) followed by the state of calamity (in which we still live), concluding the school year (in September) without ever returning to on-site teaching.

During this period, the classes of a Mathematics Course, from the Porto Accounting and Business School (ISCAP), one of the eight P.PORTO schools, took place online and, consequently, different learning tools had to be considered and used. Despite online learning outburst with the current pandemic it has long been part of the learning process ([9], [10]) as mixed form of distance learning suggested to complement and, in some cases, replace the traditional face-to-face learning.

2 BACKGROUND - OPTIONS AND CHOICES

The vast background experience, given by the participation in a European Erasmus+ Project and on some Mathematics Projects developed at P.PORTO, namely:

- **EngiMath Project** – the purpose of the project is to create and develop a shared and open platform with innovative support materials suitable for web-based assessment of mathematics for several types of engineering education curricula ([9], [11]);
- **MatActiva Project** – an Online Mathematics Education Project which aims to support and enhance mathematics education, a kind of personalized learning platform in which students can learn at their own pace several Math subjects ([12], [13], [14]);
- **Math Without STRESS (M100S) Project** – a Massive Open Online Courses (MOOC), which consists of two different Courses, Probability and Combinatorics and Introduction to Differential Calculus ([15], [16], [17]);

was an essential factor to overcome the difficulties caused by the shift from face-to-face lessons to online and virtual learning system and contributed to the definition of strategies that provide students with motivation to learn mathematics and, consequently, help them to overcome their learning difficulties. Some of the learning materials produced in these projects were also used in this course, such as: Interactive PowerPoints, Tutorial Videos and Quizzes.

ELearning requires a different pedagogy, especially with regard to online assessment and individual and group interactions. E-learning is not just about packing the websites with information, it is also about developing new ICT skills as well [18]. In recent decades, information and computer technologies (ICT) and eLearning have grown incredibly quickly. ELearning was initially used as an additional source of traditional teaching resources and has been implemented in different stages at Higher Education Institutions (HEI). In addition, it has become very important for HEIs in these times of confinement, as it allows them to provide many online services. E-learning consists of a process aimed to obtain a set of skills and competences from students, trying to guarantee the highest quality to the entire process, thanks to essentially, the use of Web-based technologies, a set of sequenced and structured subjects based upon pre-defined but flexible strategies, the interaction with students and the appropriate assessment procedures ([19], [20]). According to [21] and [22], the use of

eLearning brings some benefits to students, such as: time and location flexibility, which means that it is easy to access by the students wherever and whenever they are expected to learn; results in cost and time for HEI; student centred activities and learning material interactivity, it means that the student is not passively going through in the contents but that they have to solve problems, make decisions and look for portions of information; open access to learning material and maintain and update knowledge more efficiently. Therefore, nowadays educators and their students may have fascinating opportunities through the use of innovative technology and media. In this digital era, the role of educators has changed significantly. They must be able to apply digital technology, need to have an open mind-set to innovation, to new proposals and suggestions, must be flexible, creative and adaptable to new challenges, as we are living today.

In this Mathematics course, from March 16, all classes have become taught via Zoom. Zoom is a cloud-based video conferencing service that customers can use to meet with others virtually using the following features: audio, video and live chat. Its main functionalities are: one-to-one meetings, group video conferences and screen sharing [23].

In the institutional LMS (Learning Management System) platform – ISCAP Moodle – a set of materials were made available to support and complement students' schoolwork. So, they have used in their studies several Web 2.0 technologies and Mathematics sources such as Video Lectures (Fig. 1), Interactive PowerPoint Presentations (Fig.2) and Interactive Quizzes in Moodle (Fig.3).

Figure 1. Screenshot of the Video Lectures about "Exponential Function" and "Logarithmic Function"

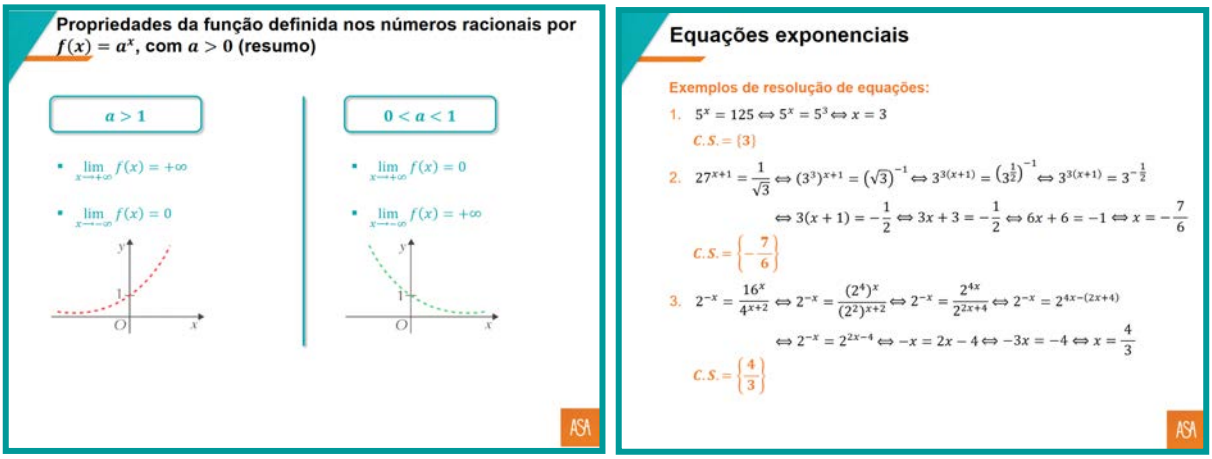

Figure 2. Screenshot of an interactive PowerPoint about "Exponential Function"

After watching each video (playing and replaying it as many times as they please) and seeing the interactive PowerPoints, students could take a small quiz, with 6 random questions, and apply the concepts addressed in video lectures and in interactive PowerPoints. In relation to these small quizzes, students could have multiple attempts at each one of them. This can help to transform the quiz taking process into an educational activity instead of a simple assessment. As the quiz is

randomized, the student would get a new version in each attempt, which is crucial and useful for practice purposes. Feedback is provided for each question, allowing the students to see one (of the possible) proposed solution, step by step. The Pool of Questions, from which the quizzes are randomised, is categorized separately by learning items (modules), as well as subdivided in difficulty levels (Fig. 3).

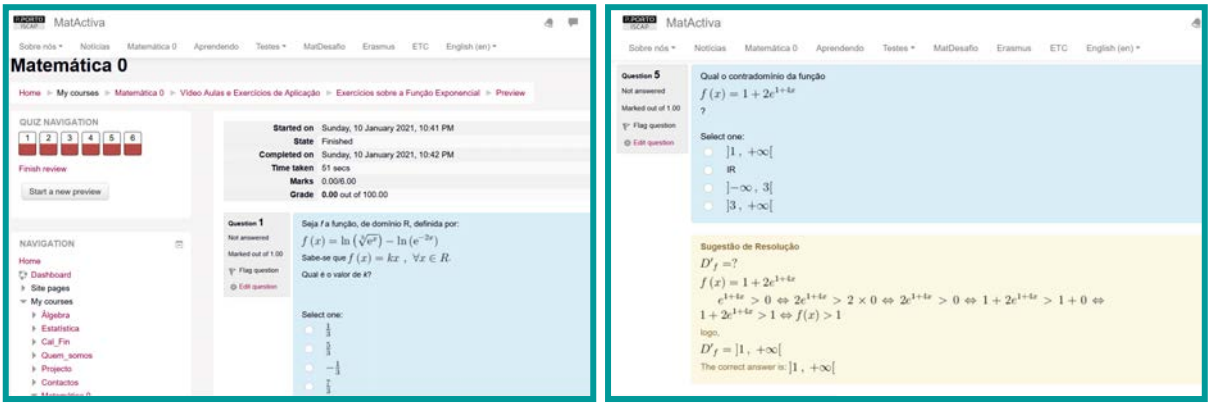

Figure 3. Screenshot of Multiple Choice Questions with General Feedback

Online quizzes and activities were combined to "test" what students have learned. Instantaneous quiz feedback and the ability to repeat lecture segments helped them to clarify some "grey" points in their minds. The quizzes' practice showed that these can also enhance learning since when students are "tested" prior to class, in a kind of learning self-diagnostic assessment, the teacher has the additional opportunity to use feedback from these tests to tailor the content addressed in the online class time. Once a module was completed, students had a test with questions related to theory and examples covered during the lectures.

3 METHODOLOGY

This study was carried out, as a different approach to the teaching/learning process in Mathematics, at a HEI. It was implemented in the Second or Summer Semester of 2019-2020 in a Mathematics Zero Course (MZC), at ISCAP, strongly supported by two online Math projects developed at the Polytechnic of Porto (P. Porto): "Mathematics without STRESS - MOOC" and MatActiva Project.

The sample of our study consisted of a total of 25 students, who attended to MZC from Zero Year Course. The participants' age ranged between 18 and 20 years old. Three modules/sections of Mathematics: Probability and Combinatorics; Introduction to Differential Calculus; and Trigonometry and Complex Numbers, were taught during the academic year. The modules Introduction to Differential Calculus and Trigonometry and Complex Numbers, were taught by using Zoom and Moodle, while the topic Probability and Combinatorics was taught by traditional teaching methods, prior to confinement.

In the past few years, pedagogical models such as Flipped Teaching, Blended Learning, Game-based Learning, Just-in-Time Teaching, Puzzle-based Learning, Competence-based Learning, among several others, are attracting instructors' attention around the world. These pedagogical models promote a new educational approach with respect to the traditional model. As already stated, the main objective of this work is to analyze the perception of the students and at the same time see the incidence of the different ICTs used in this Course.

Thus, in order to analyze the impact of ICTs in the classroom, trying to obtain some information about student's satisfaction with their implementation and, receive feedback from students about the global contentment with the model applied during the actual course, even more with the change into online teaching at the middle of the course, an opinion 8 question survey was developed using the Google Form application.

The answers to the 7 first questions in this survey correspond to a Likert scale [24], from 1 to 5, in which the meaning of each answer is:

1 Strongly Disagree

2 Disagree

3 Medium Term (neither agreement nor disagreement)

4 Agree

5 Totally Agree

The 8th and final question in this survey was an open free short-answer.

Of the 25 students that the subject had, four did not participate in the sessions and 18 responded to this questionnaire, representing 72% of the total and 86% of the attendees. Therefore, the sample is considered sufficiently representative of the population.

4 RESULTS

The results collected in the surveys for the 7 first questions on Likert scale are those shown below in Table 1.

Table 1. Students' Views on Their Needs and Expectations.

Questions		Strongly disagree (1)	Disagree (2)	Medium term (3)	Agree (4)	Totally agree (5)
1	Improves my problem solving ability			1	5	12
2	Awakens interest in the subject taught			2	5	11
3	Increases my motivation and aptitude towards the subject		1	6	9	2
4	I better understand the subject				6	12
5	It promotes autonomous learning			1	4	13
6	Reinforces background knowledge			3	6	9
7	The use of this model has been the most appropriate for this course			1	5	12

Observing the values obtained in Table 1:

- The first result in this table shows that 94,4% of the students consider that the model used improved their ability to solve problems in this subject, with only 5,6% of the students indifferent;
- 88,9% of students felt that this method awaked interest in the subject taught;
- The statement showing the lowest level of agreement was question 3 about the increase student's motivation and aptitude toward the subject, only 61,1% Agreed or Totally Agreed with this claim;
- On the other hand, 100% of students understood better de subject, 33,3% Agreed and 66,7% Totally Agreed;
- Regarding the statement "It promotes autonomous learning", the distribution of responses on the Likert scale was significantly high in the Agreed and Totally agree scores, 22% and 72%, respectively;
- Besides, 83,3% of the students think that the model applied reinforces their background knowledge, only 16,7% are indifferent to this statement;
- For 100% of the students the use of this model has been the most appropriate for this course, indicating the excellent acceptance of the method by the students.

Finally, within the comments stated by the students about the course and the model used, there are the following responses:

- "It was a very good experience";
- "It seems a good way to learn Mathematics";
- "I enjoyed this method, it is flexible, I didn't feel the pressure and helps you solve problems in an easier way";
- "With this model we have many resources available to consult, we only have to follow the steps to understand the issues and it helps a lot to be able to learn at our own pace".
- "An excellent model, which turns a difficult course into something easier and accessible."

5 CONCLUSIONS

The 2020 pandemic of COVID-19 challenged all countries around the world. Everyone had to adapt their lives and follow the instructions of the respective governments, based on the WHO directives. It turns out that education was no exception and had to find creative solutions to further develop its essential role. Portuguese Higher Education Institutions, like many others in different countries had to adapted to these challenges, in special to the transition from face-to-face to online or remote learning. Online education is a complex activity, in general the development of online courses involves a team of experts with professors, learning experience designers, computer operators and require a huge background knowledge about the functionalities and tools available on the platform used. In this quick transition, the lectures experience in distance learning methodologies and respective proactive work in open education resources was the source that enabled the presentation and operation of a course, that was not designed with that purpose, trying to maintain the quality of all the learning and teaching process, and to minimize the impact of the lack of pre-structure that occurred.

Students perceptions on satisfaction and usefulness of this model towards achievement of mathematics skills were very positive. However, face-to-face learning is still required as a component of learning to ensure good results. After this experience, the main result that comes out as mere, but grounded, suggestion is to use a well-structured blended learning approach in a post-pandemic COVID-19, subject to future analysis and leaving open numerous future work to be developed.

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