ACTIVE LEARNING DURING THE COVID-19 PANDEMIC - A TRIPLE EXPERIMENT

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Abstract

In recent times, the debate on active methodologies has been intensified with the emergence of strategies that can favor students' autonomy. The active, dynamic and constructive environment can positively influence the perception of teachers and students. One of the ways to achieve this is through the use of technologies that enhance learning. Due to the pandemic situation, the use of technologies was imperative and essential. Three higher education institutions were involved in an active learning project, involving diversified technologies and methodologies to enhance the learning of mathematics.

In the University of Aveiro, the experiment involved all the 1st-year students enrolled in the course “Complementary Mathematics II” during the second semester of the academic year 2020-21. These are students of a master’s program for pre-service teachers, preparing to become primary school teachers and mathematics and science teachers, grades 5 and 6. At the Institute of Engineering in Coimbra, the students who attended this experiment were students of Mathematical Analysis I, from the undergraduate degree in Electrical Engineering. In the Polytechnic Institute of Viseu, the students involved in this experiment were students from the Preparation Course in Mathematics (which aims to prepare candidates over 23 who wish to apply to an undergraduate degree in Business).

The methodologies used were applied during three distinct phases and according to the students’ profile, related to each course. The methodologies used were very diverse: team-based learning; flipped classroom; peer teaching; think-pair-share and exposition followed by exercise practice; problem-based learning and inquiry-based learning. The technologies were also very diversified: Desmos, Kahoot!, Quizizz, GeoGebra, Excel, OneNote, Google Docs, Zoom, Miro, Wolfram alpha, PowerPoint, calculators and videos. The use of a wide range of methodologies and technologies made it possible to teach during the lockdown imposed by the pandemic situation, and simultaneously motivated the students. In addition, they provided opportunities to adapt the learning process to the diverse knowledge and learning styles of students and increased their involvement.

Keywords: active learning, technology, distance learning, motivation.

1 INTRODUCTION

The right to education is universal. Due to the Covid-19 pandemic a new world scenario in 2020 affected the educational environment. Many of the teachers had to adapt to the new reality through the use of technologies in teaching. The use of technologies is not new and digital tools offer new challenges and possibilities for interaction and communication. Many of these challenges are found in people's daily lives, even in social structures such as school, which encompasses sociability factors that affect the lives of those who go through it. In Higher Education Institutions (HEI) it was a challenge, as the use of technologies had to maintain the same quality standards in the teaching and learning process. The integration of technologies in education needs to be done in a creative and critical way, seeking to develop students' autonomy and reflection, so that they are not just receivers of information. HEI had to adapt and adjust their methodologies for teaching in the remote modality, that is, for remote teaching. Such adaptations involve the use of different technologies and educational methodologies.

2 TECHNOLOGY IN THE TEACHING/LEARNING PROCESS

The specific literature on teaching mathematics and technologies provides powerful evidence based on small-scale studies with quasi-experimental models on the benefits of using digital tools in teaching [1,2]. On the other hand, several authors [3] have analysed the effectiveness of the teacher's use of digital tools and platforms for the teaching of Mathematics. However, these results should be considered with caution, as they depend on a number of factors, including the preparation, training and commitment of teachers in the pedagogical use of digital technology [4].

The available technological resources, such as computer algebra systems, interactive geometry software and applets, constitute new didactic tools to redefine the teaching of mathematics and, thus, develop problem solving and decision making among students, based on a reconceptualization which can lead to effective strategies to improve support in the use of mathematics at the classroom [5]. In this reconceptualization, the mathematics teacher faces the challenge of facilitating learning by providing students with access to teaching technology that includes mobile devices, specialized software and an Internet connection. Thus, new ways of teaching and, of course, of learning are established, in which students are able to incorporate Information and Communication Technologies (ICT) with the purpose of redefining the scope of their learning outcomes.

Several studies have shown that the adequate use of technologies modifies the teaching and learning process, making possible the externalization, diversification and expansion of knowledge, provides an environment of discovery and reflection that is more motivating for students [6,7] and the development of activities that are more conducive to learning, individualized teaching and student autonomy [8,9].

The technological resources in this investigation were diversified, in the scope of virtual/physical calculators, game-based learning platforms, collaborative software, Microsoft tools and finally videos and video conferencing. The majority of the resources used are free. The mathematics tools were Desmos, an online platform that allow teachers to develop remote lessons and activities for students to complete online, Wolfram alpha, a computational knowledge engine developed by Wolfram Research, GeoGebra, a dynamic geometry system, and the usual calculators used at classes, to work individually. Other resources were game-based learning platforms such as Kahoot! and Quizizz, used during the classes, to assess some topics. A collaborative environment was used during some classes, like Microsoft OneNote, Miro or Google Docs to promote collaborative work. Microsoft Excel and PowerPoint were used too. Finally, the video conferencing Zoom platform was used during the classes taking advantage of its potential.

The aim of this project was to investigate how students interact with the various tools in learning mathematics. The research questions underlying this active learning project are: What obstacles and challenges did students encounter in practice? What was the biggest evidence of change noticed in the students? What obstacles and challenges did the teachers encounter?

3 METHODOLOGY

A qualitative descriptive-longitudinal case study methodology was developed to provide an in-depth description [10]. A brief questionnaire to the students and a reflection-on-action questionnaire to the teachers was given. The open questions of the student questionnaire proceeded to a content analysis.

The study was undertaken in three Portuguese HEI involving students of different areas and levels. The teachers responsible for the courses in question are simultaneously researchers of this study.

4 RESULTS

The project was developed during the 2nd semester of the academic year 2020-21 and was divided into 3 reflection phases. Each phase lasted 4 weeks and used diverse digital tools, adapted to each topic to be addressed.

The participants were 85 students, with an average age of 22.91 years old (min=18, max=48). The students were 83.53% male and 16.47% female.

4.1 Coimbra Institute of Engineering (Instituto Superior de Engenharia de Coimbra (ISEC))

The experience at ISEC was carried out in a Mathematical Analysis I class of the Degree in Electrical Engineering. The students worked in groups of 2 to 3 in the classroom and outside it for several weeks. In the first phase the activities focused on solving nonlinear equations using the Bisection method and the Newton-Raphson method, while in the second and third phases the activities focused on numerical integration using the Trapezoid and Simpson's rule respectively. The activities were part of the continuous assessment of this discipline. Regarding the technologies used, these were quite diversified in all phases: Mathematics tools (Wolfram alpha, GeoGebra, calculator), Collaborative software (Miro), Microsoft tools (Excel, PowerPoint, Google Maps), videos and video conferencing (Zoom). The greatest evidence of change registered in the students changed throughout the year: in the first phase, the registration focuses on learning and sharing of ideas within the group itself and between groups, since the Miro Collaborative Learning software allows establish intra- and extra-group connections, students' motivation, the way in which mathematical thinking was developed both in writing and in speech and how students use the proposed tools. In the second phase, the evidence becomes: the organization of autonomous study, the responsibility for the success of each one's learning, the choices (options) made by each student. In the third phase, students were already adapted to the methodologies and learning techniques used, so the activities took place in a calm and enriching environment. They only used Google Maps for the first time, which most of them already knew how to use, and which turned out to be a very real activity.

4.2 University of Aveiro (UA)

At the University of Aveiro, the project involved all the 1st-year students enrolled in the course “Complementary Mathematics II” during the second semester of the academic year 2020-21. These are students of a master’s program for pre-service teachers, preparing to become primary school teachers and mathematics and science teachers, grades 5 and 6. Students had classes once a week four hours long.

The topics addressed during the course were: logic and geometry in the first phase, some topics of number theory (relation between decimals and fractions – length of the period and the fore period, Midy Theorem) and demonstration methods in the second phase and other topics of number theory (divisibility rules, prime factorization and Euclides’ algorithm), geometry, powers and sequences in the third phase. The distribution of topics along the semester had to be adjusted and adapted due to the lockdown period that occured.

The first phase occurred during the lockdown and therefore all the classes were online using Zoom. Given the isolation imposed by the lockdown, the teacher tried to promote as much group work as it was possible: task solving during the classes was done using breakout rooms of 3 or 4 students; homework tasks were assigned to groups of 3 or 4 students; the class was split into groups of two students and each group had to prepare an oral presentation.

Nevertheless, students also worked individually. In one situation the individual work was part of a “think, pair, share” strategy used to solve a set of tasks. In another situation the students worked individually in GeoGebra classroom but the teacher was following their work remotely.

The technologies used during the first phase were Excel (in one class), Kahoot! (in three classes - applied pre and post a learning activity), Desmos (in two classes), GeoGebra classroom (in one class), and OneNote on a pen tablet (in two classes).

During the first half of the second phase the lockdown was still in action and therefore the classes were at distance. During the second half of the phase, classes were back to face-to-face. As in the first phase, work group was intensively promoted and during the online period it followed a similar model that of the first phase. The technologies used during the second phase were Kahoot! (in 3 classes), Quizziz (in one class), Desmos (in two classes), GeoGebra (in one class), and OneNote on a tablet table (in one class).

During the last phase the teacher took advantage of the fact that the classes were face-to-face to address more abstract topics that require a more direct interaction with the students. Pencil and paper were the most used resources during these classes but still several technologies were used: Kahoot! (in 3 classes), and OneNote on a tablet table (in one class that occurred online). One of the classes was devoted to the presentation of the students’ projects (in groups of two). Within these projects students had to create and present didactic materials. All students chose to involve technologies in their materials: Kahoot!, Quizziz, Desmos and GeoGebra.

4.3 Polytechnic Institute of Viseu (Instituto Politécnico de Viseu (IPV))

At the Polytechnic Institute of Viseu, the project involved students from the Preparation Course in Mathematics (which aims to prepare candidates over 23 who wish to apply to an undergraduate degree in Business) that happened during 5 weeks of the second semester of the academic year 2020-21. Students had classes three times per week with an average of 8 hours per week.

All the classes were online using Zoom.

In the first phase, the activities focused on algebraic operations in the set of real numbers and the teacher tried to promote students' engagement mainly with individual work but sometimes also with group work. Independently if students worked individually or in groups the teacher was following their work remotely. The technologies used during the first phase were Desmos, vídeos from different resources, and Quizizz surveys.

In the second phase, the activities focused on 1st and 2nd-degree polynomial functions, as well as on sequences and systems of linear equations.

The technologies used during the second phase were Calculator; Kahoot!; Desmos; Quizziz; videos and OneNote.

The last phase was addressed initially to the complete study of a function (e.g. continuity and monotonicity) applied to the several types of functions already learned, but also to the exponential and logarithmic functions). This phase ended with the topic of derivatives and their use to help in a function complete study.

The technologies used during this phase were Calculator; Kahoot!; Desmos; Quizziz; Excel; videos and OneNote.

The greatest evidence of change observed in the students changed throughout the year: in the 1st phase, they don't do almost any homework but work a lot during the classes. In the second phase, they increased the autonomous work at home and in the classes. In the third phase, a new raising in the students' involvement in classes and also in the homework were observed. As, shortly after the end of this preparation course, some of them would have an important mathematics test, this fact created in them a necessity of increasing the rhythm of their work. On the other hand, it was noticed that throughout the phases they understood better and better the importance of active methodologies in their learning.

4.4 Students Answers

The active learning project had three phases, where the resources used were different from each other.

Figure 1. Word cloud of student's answers to a given question.

At the end of each phase, students answered the following question: "What were the biggest challenges you felt?". In Figure 1 we see the word cloud with the students' answers.

Next, we present some of the students' responses to the previous question. Code P1, P2 and P3 were assigned to each questionnaire to identify the phase; Students id is identified with the code Sn with n=1...85. Note that the Sn participant in P1 may not be the same as the Sn in P2 or P3, since the questionnaires were anonymous.

(S23, ISEC, P1) “Group work takes longer than individual work, but it makes it possible to speed up skills that otherwise could not be developed.”

(S7, UA, P1) “Develop skills in working with some technologies that you were not aware of.”

(S3, IPV, P1) “Develop some thoughts alone.”

(S42, ISEC, P2) “Dealing with certain limitations arising from the applications and technology used to work in a group. It's complicated, but it's good.”

(S9, UA, P2) “During this second block of 4 classes, I do not point out any particular challenge, as I feel that the classes and the work took place in a fluid way, without setbacks.”

(S4, IPV, P2) “Adaptation to the subject.”

(S26, ISEC, P3) “Articulation and delegation of tasks inherent to group work.”

(S3, IPV, P3) “The graphics and their functions were and are the biggest challenges I felt while learning.”

5 CONCLUSIONS

This project aimed to address the following research questions: What was the biggest evidence of change noticed in the students? What obstacles and challenges did the teachers encounter?

Over the three phases, the students at ISEC became more and more involved, quite participative, motivated, and more responsible in their learning. The collaborative environment was enriched with the change in behavior of the students involved and it was possible, in the last phase, to resort to autonomous learning in which students actively learn the contents. The biggest challenges presented by the teacher were: in the first phase, encouraging collaborative work, since these students only knew each other online and learned the Miro collaborative software; in the second phase was to show students that autonomous learning can enrich their skills and how to guide them in this learning so that learning is effective; in the third phase there was no longer any specific challenge, only directing students to achieve the intended learning objectives.

In all three phases of this study, the teacher at the University of Aveiro noticed a great involvement of the students in the classes and in the tasks carried out outside the classes. The biggest challenge was to prepare the distance classes using different resources. Today there are many resources available. All require familiarization time, and it is difficult to choose the best solution given the diversity of options.

Across the three phases, the teacher at the Polytechnic Institute of Viseu noticed that students became more and more involved in their learning process, in and outside the classes. It was also observed that students' understanding of the importance of active methodologies in their learning increased over the time. The biggest challenge was trying to manage, mainly during the two first phases, the huge time needed to prepare the classes and create new quizzes. In the third phase existed the additional challenge of thinking on innovative approaches and resources to deal with the usual difficulties of students in the new kind functions learned during this phase.

As future work the researchers will study how it will be in face-to-face mode with the use of diverse technologies and methodologies.

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