ACTA DIDACTICA NAPOCENSIA

Volume 12, Number 2, 2019 - DOI: 10.24193/adn.12.2.16

FLIPPED CLASSROOMS AND MOODLE: DIGITAL TECHNOLOGIES TO SUPPORT TEACHING AND LEARNING MATHEMATICS

Celina A. A. P. ABAR, Ubirajara Carnevale de MORAES

Abstract: This paper presents the results of research about innovative actions that use Virtual Environments to improve the teaching and learning of Mathematics in Higher Education and the participants were higher education students of Mathematics. The project was carried out in three stages. During the first stage, we assessed theoretical assumptions about the use of Virtual Learning Environments, as well as teaching of Calculus and Blended Learning. During the second stage, we describe how the project was proposed to participants. The third stage presents a proposal for the teaching of Mathematics involving the Flipped Classroom model.

Keywords: Mathematics; Blended Learning; Flipped Classrooms; Moodle Virtual Environment.

1. Introduction

The relevance of this research is due to the innovative models used in Virtual Learning Environments (VLE) within Higher Education Institutions that have explored this resource over the last few years and are constantly innovating. Some of these actions are inherent to new teaching proposals such as Blended Learning.

The project was developed over three stages. During the first stage, theoretical contributions about the use of the internet and of Virtual Learning Environments were explored, as well as the teaching of Calculus and Blended Learning. During the second stage, innovative proposals for teaching Mathematics in classrooms and in Virtual Environments were researched; and a team was created for the development of the project. The team carried out its actions according to the chosen methodology and proposed mathematical content. During the third stage, proposals for teaching Mathematics in classrooms and in Virtual Environments were developed through Flipped Classroom model.

The Flipped Classroom model is not limited to the simple inversion of the form of presenting the content and activities. This approach requires planning and a change of attitude by both teachers and students.

The proposal was well received by the participants, who took an interest in the "flipped classroom" model and revealed a positive attitude towards this new practice.

2. Theoretical Framework- Virtual Learning Environments

According to Santos and Okada, Virtual Learning Environments are a set of technical and mainly human elements and their relationship bundles in cyberspace (the internet); they have a specific identity and context created with the clear intent of teaching (Santos & Okada, 2003).

This paper is an expanded version of the presentation given to the 7th Computer Algebra and Dynamic Geometry Systems in Mathematics Education (CADGME) conference at the University Coimbra, Coimbra, Portugal, in June 2018

Cite as: Abar, C. A. A. P. & Moraes, U. C. (2019). Flipped Classrooms and Moodle: Digital Technologies to Support Teaching and Learning Mathematics. *Acta Didactica Napocensia,* 12(2), 209-216, - DOI: 10.24193/adn.12.2.16.

The best advantage of the Moodle VLE that was used in this research – beyond its technical characteristics – is the possibility of modeling activities according to target audiences and the characteristics of the course that is going to be taught. Moreover, it functions as a content manager, making materials and tasks available in a dynamic, attractive and innovative way. In this research, the Moodle Virtual Environment was used with new methods that will be presented below.

3. Teaching Differential and Integral Calculus

Integral and Differential Calculus is considered one of the most difficult subjects in certain higher education courses according to Tall (1992). This is due to the inherent difficulty of the Calculus concept, and to the fact that some students do not understand how it can be applied and have never confronted these concepts before.

Some of the difficulties that students face while learning Calculus are, according to Tall (1992); negative learning experiences in the past, poor ability in algebraic manipulation or lack of it, difficulties in understanding specific concepts, selecting and using appropriate representations, translating real-world problems into calculus formulations, absorbing complex new ideas in a limited time and students' beliefs and learning styles.

According to Irias, Vieira, Miranda & Silva (2017), after analyzing students' difficulties, the challenges are mainly due to lack of time to study. A possible solution would be the use of a special method by teachers, so that the students could dedicate more time to studying and therefore improve their performance.

As indicated in Silva, Aquino, Cavalcante, Macedo & Macedo (2010), differential and integral calculus meets the needs of engineering, technological and teaching courses in the field of natural sciences, among others. Learning this discipline will, in the future, enable extremely complex tasks to be carried out, as well as make assimilation of content easier.The Integral and Differential Calculus is one of the most important mathematical tools for engineering courses. It enables the study and modeling of real problems from various areas of performance, contributing to the improvement of quality engineering education and the training of more professionals, making them more creative and effective in solving problems of daily life and the work environment.

Given the possibility of using VLEs and students' growing interest in technology, we propose a question: how can a VLE be associated with the educational process of teaching calculus, using new teaching and learning methods?

4. Blended Learning

A student's learning process is awakened to knowledge when he is led to understand what is going on around him and make his own connections, when the content makes a difference to his real life. Therefore, it is important for the educator to review the content of learning resources employed in classrooms, giving students the opportunity to participate actively in the construction of knowledge.

One of the strategies is to stimulate students using technology – which must be used knowing its purpose, scope and efficiency. Christensen, Horn & Johnson (2008) state that technology gains space in classrooms when they are the best alternative for students' learning.

In blended learning, there are times when students are alone in the VLE and others when they study in a group, interacting with classmates and teachers, integrating traditional classroom activities with online activities. Students control the place, time and pace of their learning.

Tori (2009) refers to blended learning as two learning environments that, historically, were developed separately – traditional face-to-face classrooms and the modern Virtual Learning Environment – but are being discovered as mutually complementary. Tori (2010, p. 20) also states that there is a tendency to "let electronic and conventional learning converge towards a harmonious coexistence between face-to-face and virtual environments, in varying proportions, in future education."

Active methodologies, in a connected and digital world, are expressed through blended learning models, in many possible combinations. Blended means mixed or hybrid. It is possible to teach and

learn in countless ways, at any time, in many spaces, because this process has become much more perceptible, broad, and deep due to the mobility and connectivity that now exists: this is a more open and creative ecosystem; we learn in groups and we learn alone, we learn intentionally and we learn spontaneously.

According to Christensen, Horn & Staker (2013), blended learning is emerging as a sustained innovation when compared to traditional classrooms and is an attempt to offer "the best of both worlds" – that is, the advantages of online education combined with all the benefits of the traditional classroom.

With the presence of online education as well as technologies, teachers – having analogue and digital tools at hand – can promote discussions and reflections, stimulating the protagonism of students, who learn with and teach each other.

According to Christensen, Horn & Staker (2013), blended learning includes different models that can be used according to a course or topic's needs, in order to support all different kinds of students.

We used the model that presents four submodels: rotation by stations, rotational laboratory, flipped classrooms and individual rotation. The flipped classrooms model was the most suitable for the project because it creates favorable conditions for the teaching and learning process.

In the flipped classrooms model, students run on a fixed schedule or – at teachers' discretion – move between different modes of teaching, one of them online learning. The results show that this model of rotation applied in class meetings, if well planned, can motivate students allowing them to participate in the teaching and learning process with more autonomy, involvement and interaction with the members of the group and with the teacher.

In all models, face-to-face teaching and online teaching are alternate and blended to make up this new mode of teaching, blended learning – in which the strategic use of technology can bring countless benefits to the teaching and learning process. Moreover, during an activity, teachers can separate some time to help students with greater difficulties, while others who are more advanced continue with what was proposed. This is a form of personalization of teaching.

Depending on the objectives of the class or course, teachers can define their roles and that of students and choose the digital tools necessary to carry out the modeling of the virtual environment, considering the needs of the course.

5. Project Development

This research project followed the steps mentioned by Luckesi (2011) who suggests – beyond a literature review –, a selection of books, magazines, journals, articles, chapters and reading for documentation, as well as some phases that comply with the blended learning model.

A common plan with the *Differential and Integral Calculus I* teacher was organized and adapted to the blended learning model. According to Libâneo (2016) "the plan is a guidebook, since it establishes guidelines and means of carrying out teaching; it guides work based on the requirements of work itself."

The Pre-Calculus project carried out in the first semester of 2017 had the objective of researching innovative methodologies that are used in a free Virtual Environment of Teaching and Learning. As specific objectives, it investigated how the active teaching-learning methodologies, such as the Flipped Classroom, create favorable conditions for the learning process of Mathematics contents in Higher Education, and especially the Pre-Calculus concepts, necessary to the development of the curricular component of Differential and Integral Calculus I in Engineering and other courses that include mathematical concepts.

The proposed research project was developed for engineering students. It was important to provide the students a detailed roadmap of the virtual environment before the face-to-face meeting.

With learning tracks in the Virtual Environment containing scripts, exercises, videos, activities and templates, the flipped classroom required the students to be active and protagonists in the study

process. The learning track, see Figure 1, explained the steps that the student had to follow to participate in the project according to the model of the flipped classrooms.

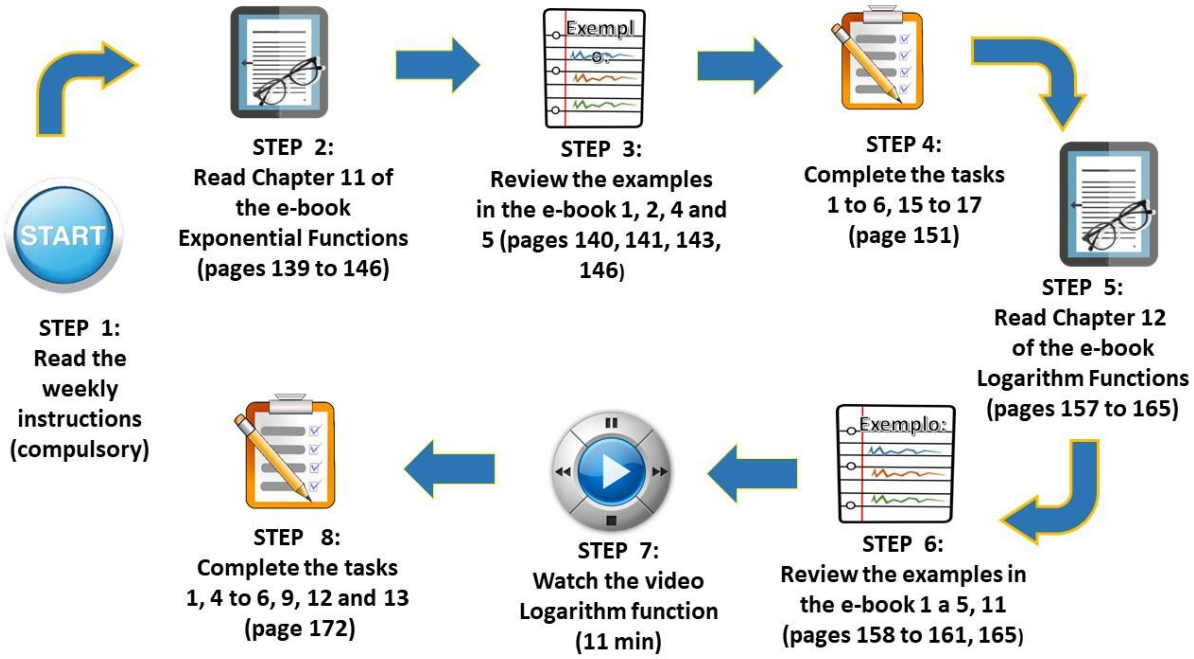

Figure 1. *One screenshot depicting the learning track available in the virtual learning environment*

A team was organized with nine teachers, eight monitors, a pedagogue, the university's Mathematics coordinator, a technician from the Technology Department and the project coordinator, who is one of the authors of this work. They all met prior to the beginning of the project and received training on the rotations model, especially on the "flipped classroom" model which was presented and discussed. The contents of Mathematics, according to the proposed objectives, due to be explored by the students were also analyzed, and each teacher was put in charge of each 8 topics that would be worked on during the meetings.

The contents defined, weekly, for the classes were the following: potentiation; notable products and factoring; functions and graphic representation; trigonometry; trigonometric transformation; matrices; determinants and linear systems.

In the first semester of 2017, a test on the basic contents of High School Mathematics was prepared and applied by the team to all incoming students of university courses in which Differential and Integral Calculus I is taught. During the first stage, the students who had taken the evaluation and whose score was between 0 and 2, in a scale from 0 to 10, were invited to enroll in the Pre-Calculus project in the Moodle virtual environment. This interval was set to represent the lower grades obtained. As few students had enrolled in the project, we have extended the invitation to the students with scores between 0 and 4. This new range would be kept for the benefit of students with low performance on the test.

In total, 141 students enrolled and participated. They were divided in classes as nine professors of Differential and Integral Calculus were participating in the project. In addition, the number of classes allows different possibilities of choosing the time to participate in the classroom meetings.

The project in the Moodle environment was structured for 10 weeks by the project coordinator and, with the collaboration of the other team members within each Mathematics topic, there was a video and about 20 activities to be explored by the students before the face-to-face meeting with the teachers.

Guidance on the "flipped classroom" model – how students should progress during the project – was made available on Moodle in an educational video, and a different weekly learning guide was distributed showing the steps to be taken.

Each weekly meeting contained three separate moments, namely:

- Pre-meeting activities: videos about each content; reading of an e-book; studying solved exercises; and solving proposed about 20 exercises available in the Virtual Environment Moodle and conducted in accordance with the different weekly tracks learning. The teacher here assumes the role of a cognitive architect, since it researches the sources of the material needed to the student, plans the activities, organizing step by step what the student will do.
- Face-to-face meeting: discussion and guidance about the video; discussion about the main difficulties found in carrying out exercises; other exercises involving discussions from this meeting; invitation to attend the next meeting.
- Post-meeting activities: list of about 5 exercises for fixation; new challenges involving the mathematical concepts studied during the week; proposals of collaborative or group activities; and participation in monitors' shifts.

The videos made available and the activities proposed on Moodle can be accessed online by teachers and students in the institution's virtual library. Access to the virtual library is exclusive to the students of the institution. The use of videos greatly contributed to the project, because it allowed students to have access to the contents and review the videos as many times as necessary whenever they had doubts.

As a partner of the teacher in this process, the student took the responsibility for his learning, considering his own time, knowledge and personal skills, guaranteeing the personalization of teaching, in a way that the Virtual Environment allowed him to advance according to his understanding.

In post-meeting activities, participants also counted on a team of monitors to help them with any doubts. In order to maximize the moment of face-to-face studying, the room reserved for monitors' shifts was strategically chosen. It had roundtables to promote interaction between participants and monitors.

6. Results

With the application of the flipped classroom methodology, we verified that the student is the protagonist of his own learning. The classroom is no longer just a place where the student is exposed to a content, it becomes a place dedicated to the student's learning through an environment that allows the exchange of experiences and clarification of doubts, being a reversed learning.

The face-to-face meetings with the teacher were no longer used for lectures, but rather for reflection to discuss the contents seen and explored in the Virtual Environment. The contents could now be worked in a different way, focusing on the difficulties encountered and the deepening of concepts and future contents. In this presential moment, when students and teachers are together, the exchange includes the applications of the content learned on the videos, reflections and discussions about the concepts.

Close to 20% of students had difficulty to use the virtual environment even with all the information and resources available. Therefore, we suggest that before its use, a training (in-person or online) is offered for familiarization with the virtual environment, to prevent it from being an obstacle in the learning that is intended to be achieved.

Few students, about 5%, stated that they prefer the classroom and learn more when copying the content from the blackboard. We believe that these students have difficulties in bringing the responsibility of learning to themselves.

Some participants of the project began to use this systematic approach in other disciplines of the course curriculum, seeking videos, sites with theoretical content and exercises on the Internet, creating their own learning trails.

In the testimonies presented we found that students believe that the use of the flipped classroom with the support of the virtual environment of teaching and learning is positive, that these two environments, online and face-to-face, favors the access to information and the organization of studies.

When submitted to a final evaluation, the students presented improvements in their performance in relation to the initial test and, at the end of the academic semester, all students participating in the project were approved in Differential and Integral Calculus I with grades higher than 7 in a scale from 0 to 10, as was informed by the respective professors of the regular discipline of calculus.

7. Conclusion

In this paper we present the development of a project proposed to higher school mathematics students, designed to investigate the effective use of blended learning. The usage of technologies involves changes in the behavior and in the relationship between all involved.

The project proposal was well received by teachers and monitors, and they showed an interest in the presented "flipped classroom" model which is different from conventional teaching.

Over the weeks, participating students reported better understanding of Differential and Integral Calculus I in face-to-face classes they attended during the project. To Tall (1992) it is important to reflect on the difficulties encountered by the students of differing abilities and experience, to obtain unbiased empirical evidence to build and test theories of learning to enable more fruitful learning experiences for students of calculus.

Using videos greatly helped the students, since they were individually able to pause during difficult concepts and review them as many times as necessary for full understanding. Trying to solve exercises before the face-to-face meeting also helped to reveal students' most common doubts, changing the face-to-face lesson strategy from problem solving to focus on doubts.

The face-to-face meetings with the teacher were no longer expository classes but spaces of reflection to discuss the content seen and explored in Moodle and that could now be worked in a different manner and with a focus on the difficulties encountered and the deepening concepts.

In the face-to-face meeting the students can work collaboratively or may do it individually relying on the assistance of the teacher whenever they need, but in a more autonomous way. In groups, the professor can be closer, ensuring follow-up to the students who need greater attention.

Project participants noticed improvements in their performance in Differential and Integral Calculus, and began to use this model in other courses, creating their own learning tracks and meeting one of the blended learning goals, the personalization of teaching, as well as unleashing students' protagonism.

After applying this model and observing students' receptivity and achievements, we hope that a new version may be produced, overcoming the challenges observed.

References

Christensen, C., Horn, M.B. & Johnson, C.W. (2008) *Disrupting Class: How Disrupting Innovation Will Change the Way the World Learns.* McGraw-Hill, New York.

Christensen, C.; Horn, M. B & Staker, H. (2013). *Is K–12 blended learning disruptive? An introduction to the theory of hybrids.* Available at: https://www.christenseninstitute.org/publications/hybrids/?_sf_s=2013&sf_paged=5

Irias, D. F.; Vieira, J. P.; Miranda, P. R.; Silva, R. C. (2017). *Cálculo diferencial e integral I: analisando as dificuldades dos alunos de um curso de licenciatura em matemática.* Available at: <http://www.cead.ufop.br/jornal/index.php/redumat/article/view/343>. Access on June 12, 2017.

Libâneo, J. C. (2016). *O planejamento escolar.* Available at: <http://www.aecep.com.br/artigo/o-planejamento-escolar--jose-carlos-libaneo.html>. Access on June 17, 2017.

Luckesi, C. C. (2011). *Avaliação da aprendizagem escolar: estudos e preposições.* 22 ed. São Paulo: Cortez.

Santos, E. O.; Okada, A. L. P. (2003). *A construção de ambientes virtuais de aprendizagem: por autorias plurais e gratuitas no ciberespaço*. Available at: <http://www.comunidadesvirtuais.pro.br/hipertexto/home/ava.pdf>. Access on: June 1, 2017.

Silva, M. A.; Aquino, L. R. C.; Cavalcante, F. L.; Macedo, A. A. M.; Macedo, L. N. (2010) *Dificuldades de aprendizagem na disciplina de cálculo diferencial e integral: estudo de caso com alunos do curso de licenciatura em química*. Available at: <http://connepi.ifal.edu.br/ocs/index.php/connepi/connepi2010/paper/viewfile/1617/882>. Access on May 21, 2017.

Tall, D. O. (1992). *Students' difficulties in Calculus*, Plenary Address, Proceedings of Working Group 3 on Students' obstacles in Calculus, ICME 7, Québec, Canada, 13-28.

Tori, R. (2009). Cursos híbridos ou blended learning. En Litto, F. M. & Formiga, M. M. M. (orgs.). *Educação a distância: O estado da arte*. São Paulo: Pearson Education do Brasil.

Tori, R. (2010) *Educação sem distância: as tecnologias interativas na redução de distâncias em ensino e aprendizagem*. São Paulo: Senac.

Authors

Celina Aparecida Almeida Pereira ABAR, Post-graduate Studies Program in Mathematics Education - Pontifical Catholic University of São Paulo (Brasil), e-mail: abarcaap@pucsp.br

Ubirajara Carnevale de MORAES, Mackenzie Presbyterian University (UPM) - São Paulo (Brasil), e-mail: ubirajara.moraes@mackenzie.br