LEARNING ANALYTICS TO SUPPORT STUDY SUCCESS BASED ON A SMALL PRIVATE ONLINE COURSE

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Abstract

Nowadays, educators are facing very fast technological changes, incomparable professional pressure, to which one must add the challenge of working with students with different mindsets, expectations and needs. The educational environment is continuously changing to adjust to the needs and demands of our society. Therefore, most Higher Education Institutions (HEI) have developed evaluation approaches as part of their quality assurance programs. There has been growing concern over the use of learning analysis in HEI, where many of the followers suggest that developments in this area may be helpful to address several challenges that educators are facing. The application range of the learning analytics practice is broad and diverse, including the gain of better insight into how learning occurs, the possible identification of students at risk of dropping out, the improvement of passing rates, and the possibility of providing personalized learning.

The purpose of the current paper is to describe an experiment to improve student engagement, educational achievement and the learning environment through a small private online course (SPOC). The paper also presents a description of the course structure and contents in a learning management system. The sample of this study, from a second-year higher education course on Financial Mathematics, consisted of 803 students, enrolled each Winter semester since 2014/2015. Traditional lectures were complemented by the application of pedagogical principles that support the inverted learning and online support through a SPOC.

The effectiveness of the methodology used is revealed by the results obtained.

Keywords: Innovation, Flipped Learning, Higher Education, Teaching Methods, Learning Analytics, Online Learning, Student Feedback.

1 INTRODUCTION

“Flipped Classroom” is a term that is associated with a modern learning and teaching approach and frequently defined as a reversal of lecture and homework, allowing class time to become more interactive. The popularity of the flipped classroom model is reflected through the increase in educational expression of opinions through the literature and various online collaborative sites. The flipped classroom method or the ‘flipped learning’ model came into general use in the early mid-2000s when it was developed by Bergman and Sams [1], the pioneers of this “movement” (chemistry teachers, at Woodland Park High School in Colorado at that time) who, in an attempt to counter the effects of student’s high absenteeism levels, began to record their lessons and post them online, allowing students to access them remotely. Therefore, the principal idea comes from reversing the traditional teaching paradigm, where the main phases of the teaching and learning process such as classroom activities and homework are reversed. The flipped classroom is then settled as a different course organization: where instructional content (e.g., pre-recorded video lectures) is assigned as “homework” – analyzed before coming to class – and in-class time is spent working on problems, advancing concepts, and engaging in collaborative learning [2]. The flipped classroom may contain a big array of out-of-class activities further than lectures, including readings, homework, and supplemental videos ([3], [4], [5], [6]). With this teaching/learning methodology, as theoretical/supporting materials must be delivered as a “pre-class” tool for students to take and analyze individually, it is extremely important to examine what “kind” of materials promote students’ engagement, as they must be responsible for class preparation ([7], [8], [9], [10]).

With all these fundamental changes, instructors have been required to quickly become familiar with this reality, creating and developing a considerable variety of tools and resources to catch student’s attention and to motivate them to actively support the knowledge in their own learning process.

The aim of this paper is to present the experience in a Financial Mathematics Course, using flipped classroom model as a pedagogical strategy to support Blended Learning – learning that combines...
features of both traditional and online education in integrated model, and win the maximum benefit from the existing techniques respectively [11]. With this study, we intend to analyse if the introduction of this flipped model can contribute to an improvement of the learning experience according to the final exam performance and students’ perception.

2 ACTIVE LEARNING

2.1 Flipped Learning

The Flipped Classroom Model is an emergent learning model which intends to increase students’ active learning, collaboration and support during the learning process, through a better allocation of teaching time [1]. More specifically, this approach suggests that teaching time within the face-to-face school sessions should not be spent on teachers’ lecturing, but instead should be invested to provide students with exceptional learning experiences within collaborative activities with their classmates as well as receiving scaffolding by their instructor [12]. Flipped Learning Network suggests the following definition for Flipped Learning ([13], p. 1): “Flipped Learning is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter”. Lowell Bishop and Verleger [14] defined the flipped classroom model as “an educational technique that consists of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom” (p. 5). The flipped classroom model (see Fig. 1) consists of some form of pre-class activity (e.g., viewing videos) before class meetings and complete individual or group activities during face-to-face lessons. Most of these activities use smartphone apps, tablets, think pair-and-share activities and online formative assessments, with the main goal of providing immediate feedback concerning misconceptions or gaps in students’ knowledge [15]. Nevertheless, according to some authors ([16], [17]), there is no standard practice for the flipped classroom model. There are many different approaches to in-class activities, which may include a combination of small quizzes at the beginning of lessons, reviews of video lectures, small-group or large-group discussions, student presentations, application projects, etc.

The cognitive psychologist Benjamin Bloom [18] made public his famous Taxonomy of Educational Objectives, commonly known as Bloom’s Taxonomy, developed for classifying learning objectives in levels. Bloom’s classification included three areas of learning: cognitive, affective and psychomotor. In his framework, he divided cognitive domain into six levels or categories, ranked from the simplest and most concrete to the more complex and abstract: knowledge, comprehension, application, analysis, synthesis and evaluation. The first three levels correspond to concrete thinking, while the top three fall into the field of creative and abstract thoughts. Anderson and Krathwohl [19] revised Bloom’s original Taxonomy that resulted in the so-called Revised Bloom Taxonomy (RBT). In this review, the
categories were divided as follows: remember, understand, apply, analyze, evaluate and create. In contrast to the original taxonomy, here the choice relied on verbs rather than nouns, since these better reflect the active nature of the learning process. At home, with the student’s preliminary study, they would work the first three areas from RBT – remember, understand, apply – while in class more complex levels can be approached – analyze, evaluate and create (Fig. 2).

![Figure 2. Connection Between Flipped and Traditional Model to Bloom’s Taxonomy](image)

### 2.2 Blended Learning

Based on a brief research through the available literature, there is no clear and unambiguous definition of the concept of Blended Learning ([20], [21]). Definitions are somewhat exclusive and sometimes contradictory, and there are few common terms used regularly. It is not easy to distinguish the term “blended learning” from other terms such as “virtual learning”, “distance learning”, “network learning”, “online learning”, “Web-enhanced learning”, “Internet-enabled learning”, among others. According to [21], this approach is a learning process based on a combination of traditional class and activities in an online educational environment using elements of asynchronous and synchronous distance learning. In their opinion the most commonly definitions are the combination of:

- instructional modalities or delivery media and technologies (traditional distance education, Internet, Web, Video/audio, any other electronic standard, e-mail, online books, etc.);
- instructional modalities, learning theories, and pedagogical dimensions;
- e-learning with face-to-face learning.

In a blended learning course, for example, students might attend a class taught by a lecturer in a traditional classroom setting, while individually, and simultaneously, carrying out online components of the course outside of the classroom. The generalized idea for Blended Learning models seems to be around the reduction of classroom lessons number, moving some lessons to an online environment.

### 2.3 Learning Analytics and Visual Analytics

The assessment of students’ performance is always a challenging and demanding task for instructors, specially in online learning environments. Educators who use online learning systems are frequently required to adapt and develop their online courses to guarantee a good performance and positive learning results from their students. By having access to the learning analytics (LA) on students’ conclusion of lessons and quiz scores, educators should have a better sense of: students’ ability to follow and understand the course contents; the topics students found difficult; students’ social interactions and knowledge contributions, etc. Therefore, educators should “desire” a Learning Management System that offers learning analytics on their online courses. A typical LA process starts with the data-gathering step. In this stage, data is collected from different learners’ activities when they interact with learning elements within a Virtual Learning Environment (VLE). The following stage is the
mining of the processed data, based on different mining techniques, such as clustering, classification, association rule mining, and social network analysis. Then, the results of the mining process can be presented as a widget, which might be included into a VLE. With appropriate graphical visualizations of the analyzed data, educators will be able to understand and interpret the information represented, reflect on the impact of their teaching method on the learning behavior and performance of their students, and draw first conclusions about the effectiveness of their teaching model.

According to [22] there is a cyclic process embraced by three different steps in learning analytics process:

• Data collection and pre-processing: the first step in any LA effort is to collect data from several educational environments and systems. Represents the collection of all the learning data needed for a particular method, and its transformation to a suitable format for that method.

• Analytics and actions: comprise the analysis and visualization of the information taken out from step 1 as well as the actions, based on that information.

• Post-processing: based on a continuous improvement philosophy. It includes all the changes to the method explained in step 1 and 2. It can involve compiling new data from additional data sources, refining the data set, determining new attributes required for a new iteration, identifying new indicators/metrics, modifying the variables of analysis, or choosing a new analytics method.

Moodle platform provides the teacher/administrator different learning analytics tools with a wide range of information reports on the numerous activities carried out by their students, in a particular subject, which can be an important tool to improve and modify the subject in question.

3 METHODOLOGY

This paper reports a study on supporting higher education students through the implementation of a flipped classroom in an undergraduate Financial Mathematics Course (FMC) in the Institute of Accounting and Administration of Porto (ISCAP) at the Porto Polytechnic (P. PORTO). The course is a second-year one in the undergraduate Accounting degree.

Having some background analytics experience, granted by Moodle platforms, MatActiva Project [23] and MOOCs [24], we have developed a FMC that used a flipped classroom model. MatActiva Project mission is to offer to ISCAP students a free, online tool, which stores wide variety of instructional Math resources, including video lectures and hundreds of exercises (all of them with a suggestion for the solution). It is a personalized learning platform in which students can individually and independently learn through an entire Math subject. One of the most engaging resources is the use of video lectures since, through them, instructors can provide multifaceted information to students and, if used creatively, videos are a powerful technological tool in the global and self-enrolment educational process [24].

Our study sample, from the Winter Semester FMC, in ISCAP, consisted of 803 students, 283 students enrolled in 2016, 262 students in 2015 and 258 students in 2014 semester. These students were separated in two groups: flipped and traditional group. In each year, the students from flipped group were the students of 2 classes from the total of 7 classes of Financial Mathematics. The flipped sample consisted of 80 students enrolled in 2016, 72 students in 2015 and 58 students in 2014 Winter semester. In both groups, approximately 90% of the students were attending the classes for the first time. The course entailed six subjects/sections (Simple Interest, Compound Interest, Ordinary Annuities, Annuity Due, Loan Amortization and Bonds) throughout the semester, and students were provided with flipped classroom model opportunities in five sections out of these six. It means that, five sections were flipped and only one section was traditionally taught during the semester. Accessing the MatActiva website (www.matactiva.com), participants could interact with all the available sections in the FMC. In each section, students had at their disposal video lectures, reading, forms and sets of online exercises and online quizzes (all with solution), related with the topic.

The flipped classroom approach entailed three lectures (contact moments) per week, with 1 hour and 30 minutes’ duration. Before class time, a set of short video tutorials, that covered the course content, were uploaded in the MatActiva site, for students to review in their own time. The first 20 minutes in class involved skimming through the tutorials while addressing student questions on their content and any concepts they had struggle with. The class time remainder was spent explaining the subject by presenting PowerPoint slides, followed by exercises resolution and work activities either individually or in group. Each week a set of online assignments, from MatActiva Project, related with the subject they
learned were given to the students to perform outside class. The attendance rate of students in the flipped classroom has been the same as the traditional class, without any drop-outs from flipped class.

Two types of data were collected: course performance and student perception. The performance data shows the results of the FMC in relation to the percentage of students who passed the courses in both the traditional and flipped classroom model. So, the results from both groups were examined in relation to each other and in relation to their standing within a particular year. We also analysed if there was any relationship between the results obtained in the final exam and the classifications obtained in the online quizzes carried out by the students in MatActiva Project. Performance data was also studied through an analysis of the spread of grades, achieved by each group in their final exam.

We have also developed a short survey in an attempt to find out how the flipped classroom model affected ISCAP Financial Mathematics students’ training, understanding and performance. The survey was given at the end of the semester to analyse participants’ global thoughts about the use of the flipped model in their classes.

4 RESULTS

Measuring the respective learning outcomes and analyzing the student activities is one of the goals of this learning analytics project. There were 552,648 log records and 43,954 sessions made by the 803 students of the FMC, with 55 sessions per student, and 11 actions per session for each student, of the flipped group, in average. The data allowed us to detect difficult parts of the course content, also which kind of resources were most engaged by the students in order to try to provide more of the same type, or improve the type of resources least engaged. It shows SCORM package, External resource and Video categories being better promoters of understanding financial mathematics concepts, and that students have more difficulty finding Homework and Task categories useful.

We have also used the final exam results to try to measure the success of the inverted classroom model. If there were substantial changes in the course results from previous years or the average course results are very different in relation to existing traditional classes, then there might be evidence of impact. Table 1 shows the relationship of results of the 2014/15, 2015/16 and the 2016/17 in the traditional classroom group against flipped classroom group.

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<tbody>
<tr>
<td>Flipped Classroom success rate</td>
<td>71,4%</td>
<td>90,5%</td>
<td>91,2%</td>
</tr>
<tr>
<td>Traditional Classroom success rate</td>
<td>49,2%</td>
<td>62,3%</td>
<td>62,7%</td>
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</table>

From this table, we can notice that the success rate for the flipped classroom version increased by 19.8% from the starting point set in 2014/15. We can also say that the success rate for the flipped classroom is bigger than the success rate for the traditional classroom in FMC. The average success rate across of flipped classroom outperform the average success rate across of traditional classroom, the average success rate for the traditional classroom improved by 13.1% in 2015/16 and 0.4% in 2016/17, while the average success rate for the flipped classroom improved by 19.1% in 2015/16 and 0.7% in 2016/17. From this we can see that there was a slight increase in overall performance in the flipped classroom version in relation to successful students. We are very pleased about the flipped classroom model results, and we plan to use it again next academic year. The student success rate in the flipped class supplanted, in a perfectly visible way, those obtained by students in the traditional class. But also, the average grade achieved among the successful flipped students, was higher than the average grade achieved among the successful students of traditional class. For flipped classroom students, in 2014/15 the average grade for Financial Mathematics was 13.3, 14.5 in 2015/16 and in 2016/17 it was 14.9 (out of 20), while the average grade for the students from traditional class was during this time: 11.2 in 2014/15, 12.1 in 2015/16 and 12.3 in 2016/17.
In addition to examining the performance data of the course, results were also extracted from the data obtained from the students’ perceptions, and these revealed the different types of training that the students did before facing the sessions that were explored in the individual moments of the room class. Table 2 summarizes the frequency of student preferences.

<table>
<thead>
<tr>
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<th>Watching flipped video</th>
<th>Watching other videos</th>
<th>Reading textbooks</th>
<th>Doing online exercises</th>
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<tbody>
<tr>
<td><strong>2016</strong></td>
<td></td>
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<tr>
<td><strong>2017</strong></td>
<td>65</td>
<td>81.3</td>
<td>52.5</td>
<td>38.8</td>
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<tr>
<td><strong>2015</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>2016</strong></td>
<td>63</td>
<td>87.5</td>
<td>47.2</td>
<td>34.7</td>
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<tr>
<td><strong>2014</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>2015</strong></td>
<td>49</td>
<td>84.5</td>
<td>48.3</td>
<td>67.2</td>
</tr>
</tbody>
</table>

From these results, it is clear that the majority of the students preferred video lectures and doing online exercises, for training, more strongly than all available written resources. The high number of students that used online exercises can, possibly, be explained by the fact that a Question Pool was created from the ground up, grouped into categories and subcategories, on Financial Mathematics Course content. The combination of questions in each category is randomized and it generates a huge number of different tests that students could solve online, wherever they are and at a time that suits them. The tests allow multiple attempts, providing automatically quantitative results and each attempt is corrected immediately. For each wrong answer the feedback is presented with a suggested step by step solution, in order to help students to understand what went “wrong” with their answer, providing and promoting self-assessment and skill development.

A large number of participating students (86.9%) stated that video lectures helped them understand the concepts studied in Financial Mathematics. No students indicated one single negative thought about flipped classroom video lectures. It is amazing that in answering the question "Online exercises helped me gain solid knowledge and skills in Financial Mathematics", the majority of students (97.7%) indicated that online exercises with the detailed solution proposed helped them perform better. Only 2.3% of the participants were neutral about the benefits of the online exercises in the flipped classroom, in terms of providing them better performance. In this same survey, to the question about the student’s preferences in relation to the flipped classroom, 66% prefer a flipped classroom. and 23.8% of the participants were neutral about the preferences related with the flipped classroom.

**5 CONCLUSIONS**

The embracement of new teaching methods, course designs, and technology allows more flexibility for all Higher Education agents and addresses the needs of students with differing learning styles. From the lecturer point of view, teaching in flipped classroom courses may be, at the beginning, uncomfortable as it demands a complete role shift from presenter to facilitator. These challenges also include a huge increased in the time spent in course preparation to find and/or create quality online resources, since it is not an easy or hasty task to create learning activities that foster student interaction and active learning. We cannot fail to mention that, initially, students may resist to this teaching/learning method and not putting the time required outside classroom, having some difficulty in completing the necessary preparation for in-class activities.

The main goal of this paper was to investigate how the integration of the flipped classroom model into a Financial Mathematics Course, in Institute of Accounting and Administration of Porto (ISCAP), affected students’ class training, learning, and achievement. In agreement with other studies on flipped classrooms ([25], [26], [27]), we verified that students in the flipped classroom preferred watching video lectures than reading textbooks about the issue they are studying. We also found that for student is very important the opportunity of doing online exercises and have access to their solutions (explained in detail). This study also shown that flipped classroom model caused an increase in student achievement in Financial Mathematics Course.
REFERENCES


