Flipped Classroom as a Mathematics Learning Space for Part-time Students

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***Abstract*—This paper presents a study developed in the implementation of flipped learning approach in a Mathematics course unit of an evening higher education degree, mostly attended by student workers. The pedagogical model based on flipped learning combined with active learning techniques, which complements the acquisition of mathematical scientific skills with autonomy, teamwork, mutual help and critical thinking, is described. Outcomes of the implementation of this pedagogical model are also presented and discussed.**

Keywords—flipped classroom, student-centered approach, active learning

I. INTRODUCTION

In the formative offer of the Portuguese polytechnic Institute of Setúbal, the evening course of degree in Technology and Industrial Management was recently restructured. This course, in an after-labor regime, aims at student workers in the industrial area and services intending to expand and deepen its range of technological and management skills. Most of the students attending this evening course have a professional activity, with very limited time to dedicate to their study, and do not demonstrate the same academic preparation as students in the daytime courses. In fact, most of student workers have interrupted their studies due to professional, financial or personal issues, which contributes to a deficit in general knowledge, in particular mathematical knowledge. However, these students possess some relevant transversal skills such as autonomy, self-discipline and self-motivation in order to improve their living conditions after completing the course. Thus, taking into account all these students' characteristics, a pedagogical strategy based on flipped classroom was established in a course unit of Mathematics, supported by a constructive alignment to achieve its learning objectives.

This paper presents the case study of the main pedagogical technique applied to a Mathematics course unit, called flipped classroom [1]. This technique, in conjunction with others, in the context of the student-centered approach, enhances the significant learning of the course unit's syllabus. The typical passive attitude of the students in the classroom is reversed through learning activities in collaborative working group and knowledge levelling. These activities make it possible to achieve the learning objectives, as well as reinforce or develop the transversal skills of employment, such as autonomy, adaptability, cooperation, constructive criticism and time management. This pedagogical technique was applied in order to work on the specific learning objectives for each class in the context of mathematical content, optimizing the student's academic work time: outside of classes students use virtual resources (texts, videos and other interactive resources) provided by the teacher to learn and deepen the contents and to carry out training tests; during classes students consolidate the knowledge acquired through knowledge levelling activities and perform summative assessments. The teacher assumes the role of facilitator of the entire learning process, guiding students´ training by managing the performance of suitable exercises, group activities, by clarifying doubts and by evaluations inside and outside the classes, using the support of an IT platform [2]. The outcomes of the application of this pedagogical technique resulted in a reduction of the drop-out rate and an increase in the course unit's success rate, compared to the two previous academic years in which the teacher-centered approach was used.

II. RESEARCH METHODOLOGY

Two research methods were applied in the study: a quantitative method and a qualitative method [3]. These methods were sequentially or simultaneously applied according to issues raised and data to be evaluated.

In the quantitative method, based on students' investigations and assessments, three different surveys were carried out during the term time: initial, intermediate and final. The initial survey, with multiple-choice questions, aimed to identify students' profile; the intermediate survey, with open-ended questions, enabled to review the students' learning process development during the implementation of active learning techniques; the final survey, with multiple-choice questions, allowed to check whether the initial objectives were achieved. All surveys were anonymous in order to protect the students' identity and privacy, encouraging them to answer with realism and truth.

The qualitative method, based on the interpretative approach given by the teacher's personal observation in classes upon the students' behavioural attitude along the learning process, provided useful information about how the learning process was being conducted.

III. FLIPPED CONCEPTS

Technology and its evolution have been affecting the educational and learning procedures with more and more impact on the lives of its users. The new computational and communication technologies enable the creation and application of new teaching techniques, allowing the learning space to expand according to the needs and possibilities of the students. Unlike traditional teacher-centered approach, the use of technology implies an active participation of students by interacting with the contents under study during their analysis, research, report production, problem-solving or content creation, among others. Hence, learning can be held anyplace, anytime and anywhere [4]. Although it is not totally consensual among different researchers, there are differences regarding knowledge structure and the use or application of technology for learning. In the literature we find inverted classroom, flipped classroom and flipped learning. Although the basic principle which sustains inverted classroom, flipped classroom and flipped learning is not new, it is still under discussion and development. As for the implementation, there are several variations that depend on the conditions of

application, the contents and the more or less ease to produce learning media and techniques.

In inverted classroom contents are first introduced and exposed outside of class and in class time learning activities and assessment are carried out in order to enable students to achieve the learning objectives of the course unit. In this context, there is the possibility, not the requirement, for students to exercise their learning in a digital environment, prepared by the teacher, limited to reading and/or viewing pre-recorded video lectures as preparation for contents' discussion in the classroom. This means that the content, instead of being exposed in class time by the teacher, is first treated by the student on a remote computer media. However, despite this preparation, it is only in the classroom that the student can "understand" if he has reached the learning objectives. One of the students' complaints about this learning approach is the lack of remote feedback and limited interaction.

Flipped classroom is a different learning approach from inverted classroom [5]. According to Kim [6], there are several nuances of flipped classroom. According to Lage [7], the application of the flipped classroom is based on the principle that "events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa". Flipped classroom is "a form of blended learning in which students learn content online by watching video lectures, usually at home, and homework is done in class with teachers and students discussing and solving questions. Teacher interaction with students is more personalized - with guidance instead of lecturing." [8]. Estes [9] presents flipped classroom in three stages: preclass, inclass and posclass learning activities. Preclass activities are typically devoted to reading content, viewing video or listening to lectures. These activities don't usually go into details, covering only the essentials. In Inclass activities are asked questions focused in content and processed in group work or individually. Postclass activities are to evaluate, develop content applications or transfer knowledge to the next context. Competences are only achieved and demonstrated at this stage.

It is essential to differentiate between flipped classroom and flipped learning which should not be regarded as interchangeable. In fact, flipping a classroom can, but not always, lead to flipped learning. The application of flipped learning is strictly related to the interaction of "The four pillars of F-L-I-P" [10]. These four pillars of good practice include: (F) flexible environments, meaning that different types of learning environments can be applied, allowing the coexistence of flexibility for learning and assessment; (L) learning culture, where the student-centered approach is valued or used in the construction of knowledge itself; (I) intentional content, where the content is intentionally designed, according to the Bloom's taxonomy, for learning activities centered on the student, inside and outside the classroom, promoting autonomy and critical thinking; (P) professional educator, where the teacher is an active observer of the quality of learning, carrying out feedback, assessment, reflection and revision and demonstrating tolerance and assertiveness during class when some kind of "controlled chaos" arises due to the change from passive to a more active attitude of students.

There is an increasing interest on the application of flipped learning in engineering education whose combination with other pedagogical learning techniques justifies the need for applied research for each specific case. This work presents the application of a pedagogical model based on active learning techniques associated with flipped learning, aiming to foster effective learning and that most students achieve and verify the intended competences outside the classroom context.

IV. Context of Application

In 2016 the evening course of degree in Technology and Industrial Management at the polytechnic Institute of Setúbal in Portugal had his educational programme (4 years – 180 ECTS) restructured. The programme was designed for student workers with a daytime professional activity in the industrial area and services aiming to improve their professional qualification by completing this course, called part-time students. So, the course's regular classes were set in an after-labor regime, in a timetable with no more than three weekdays during term time, and the pedagogical strategy adopted was blended learning [11]. Since most of part-time students have very limited time to dedicate to their study and a deficit mathematical knowledge, teaching a Mathematics course unit presented a real challenge. This paper illustrates the pathway crossed in a Mathematics course unit of the first curricular year in order to find a suitable pedagogical approach to apply.

In the 2016/17 and 2017/18 academic years the teacher-centered approach was the pedagogical approach applied at this course unit, in which lectures were given at regular classes, remote feedback was given to students by an IT platform managed by the teacher and assessment was based on two traditional summative tests. However, the success rate never reached 30% of students enrolled in the course unit and the rate of students not evaluated was always higher than 45%. In this situation, the pursuit for a new pedagogical strategy was vital. After an in-depth research and reflection about the part-time students' characteristics, the available timeframe and the learning objectives to be achieved within blended learning [12,13], the student-centered approach implemented on a flipped learning environment was the chosen one.

V. Implementation of Flipped Learning

In the academic year 2018/19, in order to enhance the application of flipped learning at course unit in the process of continuous assessment, a detailed training structure to be implemented was first built, containing "the syllabus planning, the learning outcomes setting, linking them with their ground level of cognition, the teaching-learning activities setting for each specific content, the resources to students allocation and/or creation, structuring them on an IT platform, the pedagogical strategies setting and the evaluation method definition." [14].

The whole teaching-learning process was conceived on a weekly basis. In this context, adapted variations of collaborative working group [15,16] and knowledge levelling learning techniques [17] were also applied to support a suitable application of flipped learning. The learning activities and assessment were planned under the learning objectives established for each week. Outside of class, through an IT platform provided by the teacher, students learned the contents by virtual resources (texts and videos), deepen the contents by practicing specific exercises backed up by remote feedback (individually or in group using the available forum) and carried out a training test. Afterwards, in the classroom, students consolidated the knowledge acquired through collaborative working group and knowledge levelling activities in group and performed an individual summative test. The multivariable dynamics

needed to implement this teaching-learning process can be illustrated in Fig.1 below.

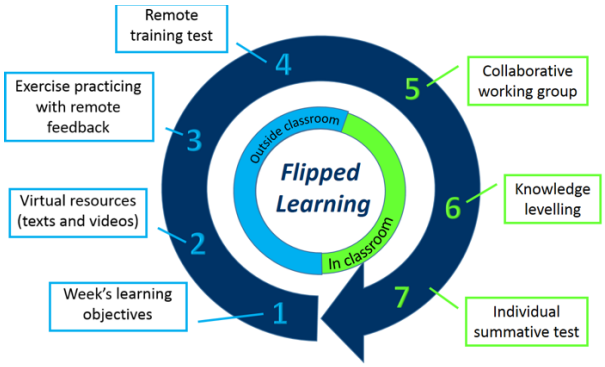

Fig. 1. Flipped learning implementation

Also, the method of evaluation implemented in the course unit was defined following the constructive alignment [14] and curricular consistency which integrates the topics to be studied and the learning outcomes to be achieved, considering the depth of contents based on Bloom's taxonomy [18]. The students' assessment consisted in eight remote training tests, eight summative tests and one optional oral presentation of group work. These assessment elements were distributed in a balanced way between all classes [19], keeping the students committed to learning throughout the term time, with the students' final score being gradually increased by each time an assessment element was performed.

In the academic year 2018/19 an initial survey was carried out in the first class of the course unit to 41 students, aiming to identify the students' study habits, the students' attitude in the classroom and the student's background.

On students' study habits, the initial survey shown that 77% of the students studied individually, 11% studied with a colleague and 12% studied in group. Concerning the preparation for evaluations, 53% of the students stated to often summarise the contents to study later, 14% stated to only prepare themselves in the run-up to the evaluation, since they had a long memory, and only 33% of the students stated to prepare themselves on a daily basis by frequent content reviews. From the responses received, it can be noted that most of the students didn´t had a regular effective study habit.

On students' attitude in the classroom, only 15% of the students stated to actively participate in classrooms. The remaining 85% stated to be passive. This passive attitude is typical on a strong teacher-centered education in which the participation of students is not encouraged. In this context, the application of collaborative working group in the classroom enhances effective learning by fostering the students' active and participative attitude.

On students' background, 46% of the students declared to have a scant mathematical knowledge; only 54% indicated having enough mathematical knowledge. Also, 83% of the students stated to never had dealt with flipped classroom or flipped learning. This last output highlights the importance of explaining to students in the first class the whole teaching-learning process.

VI. Outcomes of the Implementation

By the end of term time, a final survey was carried out to the 37 students which remained in the process of continuous assessment, aiming to report the students' feedback on the teaching-learning approach applied at the course unit.

On the weekly learning activities outside the classroom, 43% of the students stated to have spent more than 6 hours of study, 52% indicated to have spent between 2 to 6 hours of study and only 5% of the students stated to have spent less than 2 hours of study. This output reflects the students' effort to overcome their deficit mathematical knowledge. It should be noted that the study hours spent by the students were in line with the 4 ECTS (European Credit Transfer and Accumulation System) assigned to the course unit and that the students' initial perspective about their own mathematical background was too high concerning their real needs. Also, all the students reported the great importance of suitable virtual resources given by the IT platform in order to achieve the learning objectives.

On collaborative working group dynamics during the learning activities in the classroom, 73% of the students stated to almost always have worked well, 19% considered that the group have sometimes worked well and only 8% of the students considered that the group didn't work out so well. This output reflects the students' attitude in the classroom over the term time: they were encouraged to participate and to discuss the topics which contributed to a more participative attitude along the learning activities, providing a good development in their performance.

On the teaching-learning process applied, 60% of the students considered it good or very good, 35% satisfactory and 5% considered it bad. Moreover, only 3% of the students reported not to have felt difficulties, 31% had to make a bit of an effort, 47% had to try really hard to overcome their difficulties but they were able to achieve the learning objectives and 19% reported not to have achieved the learning objectives although they have tried really hard. Even so, 86% of the students stated that their effort to achieve the learning objectives was worthwhile.

On the method of evaluation, 76% of the students considered it good or very good and the remaining 24% as satisfactory.

Overall, 78% of the students would like flipped learning approach to be applied to other course units, 73% stated that this course unit was more demanding, and 57% more motivating, than other course units. This output is quite relevant since it reinforces the application of flipped learning approach as a suitable learning space of Mathematics for part-time students

It was also important to notice how collaborative working group and knowledge levelling activities in the classroom provided a more effective learning, acting as a complementary support of flipped classroom by fostering the students' motivation. In addition, the balanced distribution of the assessment elements throughout term time, with the students' final score being gradually increased by each time an assessment element was performed, was a crucial aspect to keep students committed and motivated.

The general positive feedback given by students about the implementation of flipped learning approach in the academic year 2018/19 enhanced the maintenance of this approach in the following academic year.

In the academic year 2016/17 this course unit had 55 enrolled students, in 2017/18 the number of enrolled students

increased up to 75, in the academic year 2018/19 there were 83 enrolled students and in 2019/20 this course unit had 81 enrolled students. In Fig.2 bellow, the students' performance is presented by academic year.

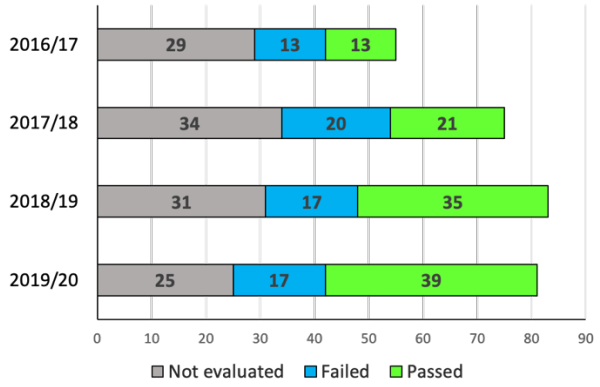

Fig. 2. Students' performance

It can be noted that the rate of students enrolled and not evaluated, concerning students that never attended any regular class during term time nor the final written exam, in the academic year 2018/19 was around 37%, while in the previous academic years this rate was always higher than 45%. Moreover, the success rate exceeded the rate of not evaluated students for the first time in 2018/19, reaching 48% of passed students in 2019/20, being the highest rate ever accomplished in this course unit. Notice that in 2016/17 and 2017/18 the success rate had never exceeded 28%.

VII. Conclusions

Mathematics is a cross-cutting scientific area whose contents, although necessary for students' training, are hard to assimilate by part-time students having a professional activity and a deficit mathematical knowledge. So, the application of active learning techniques, within the student-centered approach, foster part-time students to achieve the learning objectives of the Mathematics' course unit.

The outcomes of the application of flipped learning, along with collaborative working group and knowledge levelling on a weekly assessment basis, resulted in a reduction in the drop-out rate and an increase in the success rate, compared to the two previous academic years in which the teacher-centered approach was used. Moreover, the number of students in the process of continuous assessment almost didn't decreased, keeping the students engaged in the course unit over the term time. Thus, it seems to be a strong relationship between the application of the flipped classroom backed up with other active learning techniques (collaborative working group and knowledge levelling) and the improvement of the part-time students' drop-out and success rates.

Also, this form of backed up flipped learning contributes to change the typical students' passive attitude in the classroom, providing a more efficient and fruitful learning space for part-time students.

In terms of teaching work, even though it is a rewarding experience, it is very demanding and challenging. Everything must be properly considered and measured, in and out of the classroom, due to its multivariable dynamics. In addition, the teacher must also be available during term time to all students for feedback, in real time, as needed.

Finally, due to its flexible feature and reduced face-to-face need, this adapted way of implementing flipped learning approach also provides a suitable learning space to fit higher education in a scenario of global pandemic like coronavirus.

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