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The Flipped Classroom and Higher Education - Experiences with Computer Science Students

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Abstract*—*This paper presents the main results of the experiments carried out during a field investigation on the teaching and learning methodology of the flipped classroom, variant of b-learning education, within the scope of the PhD program in Information Sciences (in Systems, Technologies and Information Management) from Fernando Pessoa University in Porto - Portugal. The field research was methodologically oriented around Action-Research and was conducted between 2015 and 2019 with one hundred and fifty-two (n = 152) students from the higher education in Computer Science courses of two higher education institutions. The students were subjected to the methodological context of the flipped classroom, and the study focused on finding answers around the efficiency and effectiveness of this teaching methodology, by collecting data in two specific approaches, one related to behavioral aspects and the other around students affective aspects, given their individual experience in the teaching and learning process of the flipped classroom.

Keywords*—*flipped classroom, b-learning, teaching and learning process, active teaching methodologies.

I. INTRODUCTION

The exponential growth and popularization of the Internet over the last twenty-five years and the consequent advancement of digital technologies has significantly influenced the interaction of people in their relationship with information and knowledge, giving rise to a network society with directly impacts the educational environment, at different levels of education, which stimulates the development of new teaching methodologies, such as the flipped classroom example, one of the variants of b-learning that takes advantage of the digital resources of computing that are being executed[1](Gokalp, 2013), implementing them specifically in the context of the face-to-face class (F2F) as in an e-learning environment.

The implementation of the flipped classroom emerged in the 1990s, empirically and with methodological variations, initially without the denomination that is currently used to invert the class. [2](Moran e Milsom, 2015).

Since 2006 K12American teachers Jonathan Bergmann and Aaron Sams, authors of the title reference book, "Reverse Your Classroom: Reach Every Student in Every Class Every Day," start promoting and implement an flipped classroom in US schools, period when the flipped classroom methodology becomes increasingly visible in the educational environment [3](Lopes, Gouveia e Reis, 2016).

The teaching methodology of the flipped classroom is initially to provide students with online theoretical content of the subject that will be worked later with the teacher in F2F, aiming to concentrate the classroom in an environment of debates, exercise resolutions, project design, practice activities, etc. Among the most used techniques in the flipped classroom, we highlight the availability of short videos in an e-learning environment [4](Bergmann e Sams, 2012), in which the teacher presents the fundamental content of the subject to the students, which can be accessed through the Virtual Learning Environment (VLE) on the Internet. In a F2F class, in general, the teacher puts himself most of the time in active conduct when explaining the subject, while students remain passive listening to the explanations. The flipped classroom as an active teaching methodology proposes a modification of this posture, aiming to streamline and modify the interaction between the teacher and the students, so that they are jointly active during the whole class in F2F context, concentrated predominantly in the accomplishment of activities, due to the fact that the introduction to the content of the subject was previously

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done in an e-learning [5](Valente, 2014), as shown in the Fig. 1[6](The University of Texas at Austin, 2019).

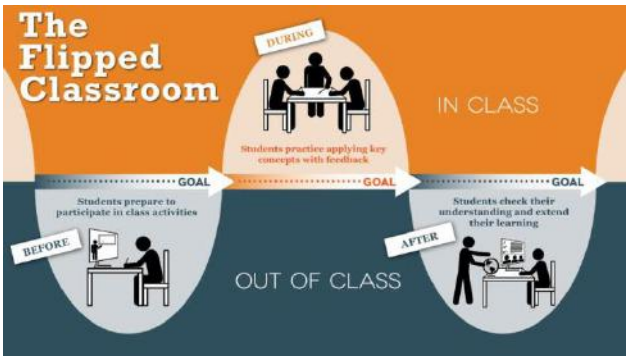

Fig.1: The Flipped Classroom

The flipped classroom presents methodologically, a specific organization proposal about the distribution of the contents of the subject and the realization of classroom activities in the VLE and the F2F context, as shown in the example of Table 1 [4].

Table 1: Traditional versus flipped classroom

Traditional Class		**Flipped Classroom**	
Activity	*Time*	*Activity*	*Time*
Warm up activity	5 min.	Warm up activity	5 min.
Go over previous night's homework	20 min.	Question & answer time on video	10 min.
Lecture of new content	30-45 min.	Practical and independent guided and/or lab. activity	75 min.
Practical and independent guided and/or lab. activity	20-35 min.		

Analyzing Table 1, we found that the flipped classroom methodology significantly reduces the approach of the expository method during the classroom in the context of F2F, assuming that the stage of exposure of the contents of the subject (theoretical materials, manuals, videos, multimedia resources, etc.), was already fulfilled by the students in the previous class in e-learning environment, being viewed the video on the subject of the class, read and studied the theoretical contents in digital format. In In the flipped classroom methodology, the F2F class has as its main purpose to make students concentrate most of the class time on the development of individual and/or group practical activities, laboratory or not, according to the specificities of each class teaching area, with the objective of providing a dynamic of strong interaction between the students and the teacher, with the student having the opportunity to be a protagonist in his teaching and learning process, supported by the teacher who guides the development of student learning, acting as an "experienced guide".

About to the context of the flipped classroom, the need for protagonism of the students, especially in the online class, is a critical factor for the effectiveness of the teaching and learning process in the context of the methodology, as the study of the contents made available to students in the VLE is an introductory and preparatory pre-class for the classroom, requiring a high level of autonomy and engagement by students, with the need for intense dedication in online study and monitoring constant performance of students by the teacher at risk of the flipped classroom methodology will not result in practice if students do not join the study of the online component of the class, which will require the teacher to change the teaching methodology, probably by returning of the implementation of the traditional expository teaching methodology [7](Jovanovic *et al.*, 2019).

The scientific literature shows that the flipped classroom teaching methodology can be implemented at any educational level, in different areas of knowledge, whether in academic or corporate teaching. Within this assumption, the main objective of this paper is to present the results obtained from the field experiments conducted around the implementation of the flipped classroom in the context of Higher Education.

II. METHODOLOGY

The research methodology of this study is action research, whose creation has an indefinite origin, although recurrently the scientific literature credits the creation of the method to the German psychologist Kurt Lewin, due to the fact that he defined the term "action research" [8](Tripp, 2005). Within the context and characteristics of this study, we consider the action research approach, as the one that is best adjusted to the investigative process performed, about the potentialities and challenges provided by the implementation of the flipped classroom teaching methodology, due to the possibility of autonomy of the teacher-researcher in the active conduct of the research process, intervening and interacting directly with the experimental sample, being a participant element of the field experiments. The target population of this study is the student (n = 152) of Higher Education from two institutions located in the city of Porto (Portugal), Fernando Pessoa University and the Higher Institute of Advanced Technologies. In the present study, four research instruments were used, divided into two categories, namely: 1 - procedural instruments, composed by the teacher's protocol and the student's guide, and 2 - data collection instruments, composed by the observation grid and the survey.

In the fieldwork of this study, about data collection, some research techniques related to descriptive and correlational quantitative approaches were adopted in the experiments,

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respectively by questionnaire surveys, hypothesis testing, and qualitative research approaches. using the participant observation technique, supported by observation grids. Within this assumption, four hypotheses were also elaborated for statistical testing, to obtain some information considered relevant and that cannot be perceived, only by statistical analysis of relative and absolute frequencies.

III. RESULTS AND DISCUSSION

The results of the field investigation, which were obtained by performing a total of nine experiments, one pilot and eight more, with part of the data obtained through the observation grid and the other part by the questionnaire survey, instruments already mentioned in this paper.

Statistical analysis involved measures of descriptive statistics (absolute and relative frequencies, means and their respective standard deviations) and inferential statistics. The significance level for rejecting the null hypothesis was set at (α) <= 0,05. Exploratory Factor Analysis, Cronbach's alpha internal consistency coefficient, Pearson's correlation coefficient, Student's t-test for one sample, Manova Repeated Measures, Fisher's test, and Mann-Whitney test were used. The normal distribution of the variables was analyzed with the Shapiro-Wilk test. The homogeneity variance was analyzed with the Levene test.

According to the frequencies presented in Table 2, about the consolidation of the data obtained in the experiments through part 1 of the observation grid about the e-learning component of the class, the students mostly watched the video available (69,7%), in contrast to adherence to the theoretical study of the subject was relatively low (36,2%) and median understanding of the content provided (51,3%).

Table 2: Objectives of students in the e-learning environment

	Have you studied the subject available on the e-learning platform?	**Did you watch the video available on the e-learning platform?**	**Did you understand the material available on the e-learning platform?**
Yes	55 students (36,2%)	106 students (69,7%)	78 students (51,3%)
No	97 students (63,8%)	46 students (30,3%)	74 students (48,7%)
Totality	152 students (100%)	152 students (100%)	152 students (100%)

About student surveys supported by the Google Forms online tool, volunteer students were required to answer all of the questions, which were organized into three (3) parts: 1-Sociodemographic characterization (5 questions); 2-Affective perception about ICT in e-learning and classroom teaching (2 questions); 3-General perception about the flipped classroom methodology (20 questions). One hundred and twenty-two students (N = 122) collaborated in the study, equivalent to 80,3% of the total sample of one hundred and fifty-two students (N = 152) with a mean age of 20,6 years and predominantly male gender as shown in Table 3.

Table 3: Gender of surveyed students

Gender	**Frequency (N)**	**Percentage (%)**
Male	115	94,3
Female	7	5,7
Totality	122	100

In the questionnaire survey, students were asked to choose up to four words out of a total of fifteen words representing feelings, which best represented their affective perception about the use of Information and Communication Technologies (ICT) in F2F teaching and e-learning. As shown in Table 4, when asked students about “The use of ICT in classroom teaching causes me”, the most mentioned affective perceptions are Enthusiasm (72,1%) and Joy (59,8%).The same question made in the context of distance education, when stated to students about “The use of ICT in e-learning education causes me”, the most mentioned affective perceptions are Enthusiasm (59%) and Joy (45,9%) as shown in Table 5.

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Table 4: Affective perception with ICT in classroom teaching (F2F)

Affective perception	Frequency (N)	Percentage (%)	Affective perception	Frequency(N)	Percentage (%)
Enthusiasm	88	72,1	**Anxiety**	12	9,8
Joy	73	59,8	**Affection**	5	4,1
happiness	56	45,9	**Boredom**	5	4,1
pleasure	54	44,3	**Anger**	4	3,3
Inspiration	52	42,6	**Contempt**	3	2,5
Excitement	39	32	**Fear**	2	1,6
Indifference	21	17,2	**Hate**	0	0
Frustration	13	10,7			

Table 5: Affective perception with ICT in distance learning (e-learning)

Affective perception	Frequency(N)	Percentage (%)	Affective perception	Frequency(N)	Percentage (%)
Enthusiasm	72	59	**Anxiety**	14	11,5
Joy	56	45,9	**Affection**	9	7,4
happiness	40	32,8	**Boredom**	6	4,9
pleasure	35	28,7	**Anger**	6	4,9
Inspiration	31	25,4	**Contempt**	5	4,1
Excitement	29	23,8	**Fear**	5	4,1
Indifference	27	22,1	**Hate**	3	2,5
Frustration	26	21,3			

In the last and third part of the questionnaire survey, the students underwent a series of affirmation about the flipped classroom to demonstrate their level of agreement or disagreement (Likert scale). The Table 6 presents the data consolidation (frequencies, means, and standard deviation) of the third part of the survey, highlighted in light gray in the most frequent answers. The answers that motivated the highest levels of agreement were: "The possibility of using videos as an aid in solving exercises for the preparation of tests and exams is a facilitating aspect" (mean = 3,4) and "The video allows to revisit the contents when I do not understand them well, which is more difficult to do during a classroom class "(mean = 3,27).The survey affirmation that recorded the highest levels of disagreement was: "Video quality is not good, so content is not noticeable" (mean = 1,97).

Table 6: The general perception of students about the flipped classroom

Subtitle: 1 - Totally disagree 2 - Partly disagree 3 - Partially agree 4 - Totally agree M – Mean SD – Standard deviation	1	2	3	4	M	SD
1. I found it difficult to solve the exercises proposed in the flipped classroom classes, regardless of the viewing of the videos.	23,0%	42,6%	31,1%	3,3%	2,15	,81
2. If I had summarized the requested video, my performance in solving the exercises on this video would have been better	9,0%	24,6%	50,0%	16,4%	2,74	,84
3. In the flipped classroom classes it took me less time to realize what was required in the proposed exercises when compared to the traditional classes.	4,1%	18,9%	57,4%	19,7%	2,93	,74
4. In the flipped classroom classes I felt less difficulty in solving the proposed exercises when compared to the classes without the flipped classroom.	5,7%	17,2%	59,0%	18,0%	2,89	,76
5. In the flipped classroom classes I took less time to perform the proposed exercises when compared to classes without the flipped classroom.	4,9%	23,0%	54,1%	18,0%	2,85	,77
6. In the classes with flipped classroom I had less difficulty in solving the proposed exercises because I felt more identified with this type of class.	4,9%	19,7%	58,2%	17,2%	2,88	,74
7. I consider the flipped classroom approach to be an advantage in my learning process.	3,3%	6,6%	50,8%	39,3%	3,26	,73

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8. The content on the subject of the video made me know how to select what I needed to use in solving exercises.	1,6%	15,6%	63,1%	19,7%	3,01	,65
9. The mode of exemplification that was done in the video made me understand it better and thus know how to use it in solving classroom exercises.	0,8%	13,9%	68,0%	17,2%	3,02	,59
10. I felt "somehow" that the videos had the teacher's presence, so I paid more attention to the contents of the video than to read them in a book or manual.	3,3%	17,2%	52,5%	27,0%	3,03	,76
11. Video allows you to revisit content when I don't understand it well, which is more difficult to do during face-to-face class.	1,6%	6,6%	54,9%	36,9%	3,27	,66
12. The ability to use videos as an aid in solving exercises for test and exam preparation is a facilitating aspect.	0,0%	3,3%	53,3%	43,4%	3,40	,56
13. The teacher gives me more attention to flipped classroom classes.	10,7%	19,7%	50,8%	18,9%	2,78	,88
14. The exercises proposed in the classroom classes required content that was not explained in the videos.	16,4%	33,6%	43,4%	6,6%	2,40	,84
15. The video content is static, if I don't understand it, I can't apply the concepts in solving exercises in the classroom.	7,4%	33,6%	52,5%	6,6%	2,58	,73
16. I do not have enough time to watch the videos outside of classroom classes.	24,6%	28,7%	37,7%	9,0%	2,31	,95
17.The flipped classroom is a very laborious approach to teaching in the subject study process.	4,9%	32,8%	48,4%	13,9%	2,71	,77
18. The video quality is not good, so it makes the content unnoticeable.	36,1%	35,2%	24,6%	4,1%	1,97	,88
19. I better understand the subject when I watch the video and the teacher focuses the classroom with exercises.	4,9%	11,5%	59,8%	23,8%	3,02	,74
20. The flipped classroom allowed me to solve more classroom exercises and better clarify my doubts with the teacher.	2,5%	11,5%	52,5%	33,6%	3,17	,72

We developed four hypotheses for statistical testing, to obtain some information considered relevant and not perceived only by the statistical analysis of relative and absolute frequencies. The following are the hypotheses elaborated for the present study:

Hypothesis 1 (H1) - Students, independently of age, gender, academic level and semester, have similar affective perceptions in dealing with digital technologies, in the F2F and e-learning environment in the context of the flipped classroom.

The statistical analysis of H1, indicates that students of courses in computer systems, especially in the 3rd and 4th semesters, in e-learning and classroom classes, present a significantly higher positive affective perception than students of the undergraduate degree in Computer Engineering of any degree without significant differences in age and gender.

Hypothesis 2 (H2) - Students, regardless of age, gender, academic level and semester they are in, similarly evaluate flipped classroom classes (analysis carried out through the dimensions obtained by Exploratory Factor Analysis: "advantages", "difficulties", "video advantages", "video/teacher relationship" and "obstacles").

The statistical analysis of H2, indicates that female student regardless of the course and students of courses in computer systems regardless of gender, in the dimensions "advantages" and "video/teacher relationship" are the ones who most positively evaluate their experience with flipped classroom methodology, no matter the semester.

Hypothesis 3 (H3) - The students who understood the subject were the students who watched the video and studied the subject available on the e-learning platform.

In the statistical analysis of H3, students who claim to have understood the subject online, through video viewing and reading of complementary theoretical material, are proportionally and significantly superior to students who claim to have understood the subject, only based on video viewing or reading of the theoretical material. Some few students, who claim to have understood the subject without even viewing the video or studying the theoretical content, tend to indicate that they have prior knowledge of the subject or answered randomly when asked.

Hypothesis 4 (H4) - The number of students per group and the academic level does not significantly influence the completion of the proposed activities in the F2F component of the flipped classroom.

In the statistical analysis of H4, it is concluded that the number of students per group is not significant in the performance of the activities resolution, and the students coming from the computer systems courses completed significantly more activities compared to the students of the computer engineering courses.

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IV. CONCLUSION

In this study we focus mainly on the flipped classroom b-learning teaching methodology, having verified that this methodological approach has a positive potential in its structure to balance the relationship between teachers and students in synchronous and asynchronous teaching environments involving digital technologies. In F2F classes or the context of e-learning, because the flipped classroom has a set of specific procedures that guide its methodological implementation, this aspect allows mitigating some challenges in the context of the teaching and learning process in the context of e/b-learning.

We found in the study that the students of the Higher Education sample investigated, have a relevant disposition for the use of digital technologies in their teaching and learning process, either in F2F or e-learning, demonstrated by the significant positive affective perception presented in the results experimental, whether in the implementation of b-learning teaching methodologies such as the flipped classroom, with the teacher prioritizing the form and strategy of content implementation.

Regarding the VLE digital resources in the e-learning context, students tend to show greater motivation, when they somehow feel the "presence" of the teacher, this is made clear by the high adherence to the didactic video available in the field experiments. We also observed in direct contact with students in F2F, during the experiments, a strong motivation about the use of videos, in contrast, we noticed a resistance of students to adhere to the study of theoretical content in e-learning.

Regarding the efficiency of the flipped classroom, this study showed us that efficiency varies around some relevant characteristics, such as:

1. It requires a high level of teacher work and creativity in developing content and then properly organizing it into the F2F and e-learning components of the class, which may take some time before the content is properly adjusted;
2. Demands a high degree of student role in wanting to be self-directed in their teaching and learning process, especially in the e-learning component of the class, which implies a cultural change from an academic point of view, which can be persistently achieved mainly in the context of Higher Education;
3. Demands that teachers receive training and guidance on active methodologies, with the encouragement of higher education institutions, concerning the purely technical aspects of digital technologies, but mainly how to generate educational value in methodological terms in the field teaching and learning process in an inverted classroom context.
4. The efficiency of the flipped classroom may increase through the elaboration of specific procedures around teaching techniques, adapted to the academic reality of higher education institutions, regarding the interaction between teachers and students with the methodology, providing a gradual increase of expertise over time, composing a set of "lessons learned" that will be helpful to the process of practical evolution about the implementation of the flipped classroom.

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