FLIPPED CLASSROOM STEM TEACHING: AN INNOVATIVE PRACTICE OF TECHNOLOGICALLY SUPPORTED TEACHING OF PHYSICS

Nikolaos Diamantopoulos, Anastasia Brami, Ilias Spanos

1st General Lyceum of Aigio, Greece

Corresponding Author: Nikolaos Diamantopoulos, ndiaman@sch.gr

ABSTRACT: This paper proposes the use of the Flipped Classroom (FC) model in Physics lesson combined with STEM education. The flipped classroom shifts the boring and passive for the student theoretical part of teaching from school to home, leaving more time for the teacher at school to apply learner-centered, experimental learning techniques. On this basis, the aim of this paper was to examine the possibilities, the prerequisites and the results of implementing a flipped classroom model as a form of blended learning. In particular, in this study we present the design, implementation and results of an action research for the case of Physics lesson, in the lesson of gravitational acceleration, in our upper secondary school with the use of technology like LAMS and Edpuzzle. Two classes, 49 students, aged 16-17 years and two teachers participated. The research data showed that the pilot application of the flipped classroom method had positive effects on students and teachers and confirmed the significant benefits mentioned in international bibliography.
KEYWORDS: Flipped Classroom, LAMS, Edpuzzle, STEM, Physical Sciences.

1. INTRODUCTION

Traditional teaching is strongly criticized for the passive role of the student ([RRS13]). At the same time, the development of technology over the past few decades has made distance education more easily achievable and accessible. Nevertheless, distance learning remains inadequate in terms of the students' social interaction, which is essential to achieving learning. The combination of traditional classroom teaching and distance learning leads to blended learning. In the blended learning, the educational procedure is divided to time outside class and in-class. The students are studying on their own, with the help of digital media and of Internet outside class, while learning is completed inside class, under the supervision of the teacher ([Gra14]).
Flipped Classroom (FC) is a form of blended learning. The central idea of the FC is for students to prepare themselves at home before the lesson, watching interactive videos on the theory of the lesson, while in the classroom they can solve problems, process difficult concepts, perform experiential activities and learn collaboratively.

On the other hand, STEM (Science, Technology, Engineering and Mathematics) is an educational approach that has been designed to introduce the teaching of Mathematics and Physical Sciences, which is vital for a basic understanding of the world as well as techniques of Engineering and Informatics, which are the means of interacting with the world. It is a new meta-scientific sector, in which the solution of a problem, the inquiry learning and the creative engagement of learners play the major role in the curriculum. The activation of students in Physics course is a major objective of modern education. An approach that contributes to activating the students is the STEM education with robotics.
The aim of this paper is to investigate the possibilities, conditions and results of the implementation of the FC model in parallel with STEM as a form of blended learning for the Physics course.
The research questions that this work attempts to answer are:

1. Can the FC model be applied to secondary Physics education as a form of blended learning with support of ICT and to what extent?
2. In which Physics units/lessons and to what extent can the FC model be applied?
3. How can the implementation of the FC model be evaluated in terms of learning outcomes and its acceptance from students in comparison with the traditional method?

Follows the description of
(a) FC model,
(b) LAMS learning management system and
(c) The pilot use of FC model and STEM in the teaching of Physics in the field of gravitational acceleration.
We end up with the findings from the evaluation of the case study and the conclusions.

2. THE FC MODEL

The Flipped Classroom (FC) model is a blended learning model where students learn by watching video lectures or other educational material at home while homework is done in the classroom with the teacher and students discussing and solving problems. The teacher in classroom supports the students whenever they have difficulty. Their role is shifted from the traditional lecture to guidance, support and personalization ([BV13]). The implementation of FC model requires the use of distance learning platform, and here comes the contribution of technology. Using video or other digital material outside the class by itself is not enough. The emphasis should be on students becoming an active part of their own learning rather than objects of teaching.

In theory, the FC model is based on Piaget's collaborative learning, Vygotsky's contructivism and Kolb's experimental learning ([BV13]). According to Piaget, the experience and social interaction that happens in classroom activities of the FC class are important learning factors. Collaborative learning, i.e. collaboration between students and between students and teachers in the learning process, has been proven to improve understanding and encourage students to engage in discussions, thus leading to the creation of knowledge through dialogue ([KB13]). Also, according to Vygotsky, the social environment greatly affects the students' perception of the world. In the FC class, there is plenty of time for the students to interact with their classmates and the teacher. Finally, Kolb highlights experience and action as components of the learning cycle, i.e. the elements promoted by the FC, since this model enables the students to pass the passive role in the home so that they can devote time for action and experience in the classroom.

The FC model comprises three stages of preparation and application (a) prior to class, (b) in class and (c) post class ([EIL14]). The initial and final phases (before and after the class) are carried out by the students remotely, from home, using a digital platform and appropriate educational material. Students can see the digital material as many times as they want, focus on whatever points they want in their own space and at their own pace. While watching the video lecture, students can also control their level of knowledge and depending on their performance and after finding out their potential weaknesses, they can go back to the digital material, watch the video again or extend their knowledge further if they want ([EIL14]). The intermediate phase (within classroom) takes place in the classroom, using active and participatory teaching techniques. In the FC, students are encouraged to combine the information they have obtained outside the classroom and interact with it and their classmates in a way that demonstrates that they have become active users of the information based on their personal experiences, critical thinking and group interaction ([BOW11]).

For our action research, the module of gravitational acceleration was selected from the Physics course, which according to the curriculum is taught in two hours, preferably in the laboratory.

3. THE PLATFORM LAMS

The Learning Activity Management System LAMS (http://lamsfoundation.org) is a platform that implements the ideas of learning design ([Dal03]). LAMS supports designing, writing, managing and monitoring the implementation of courses in the form of sequences of learning activities. LAMS enables the creation of not only individual but also collaborative learning activities, both in person and online. The creation of sequences of learning activities can be done by manipulating virtual object representations in a particularly friendly user interface. The sequences of learning activities for a scenario, a lesson or a part of a lesson can be saved and reused ([P+10]). The LAMS platform was chosen because it enables an easy way of supervision. In other words, we can follow the course of the students' study and gather statistical data, such as the student's time spent in the various modules, their performance in various exercises, etc.

4. THE LESSON OF GRAVITATIONAL ACCELERATION WITH FC AND STEM

We design a lesson for gravitational acceleration, based on the teaching objectives as they are mentioned in the curriculum and adapted to the three parts, which correspond to the three phases of FC model (Figure 1).

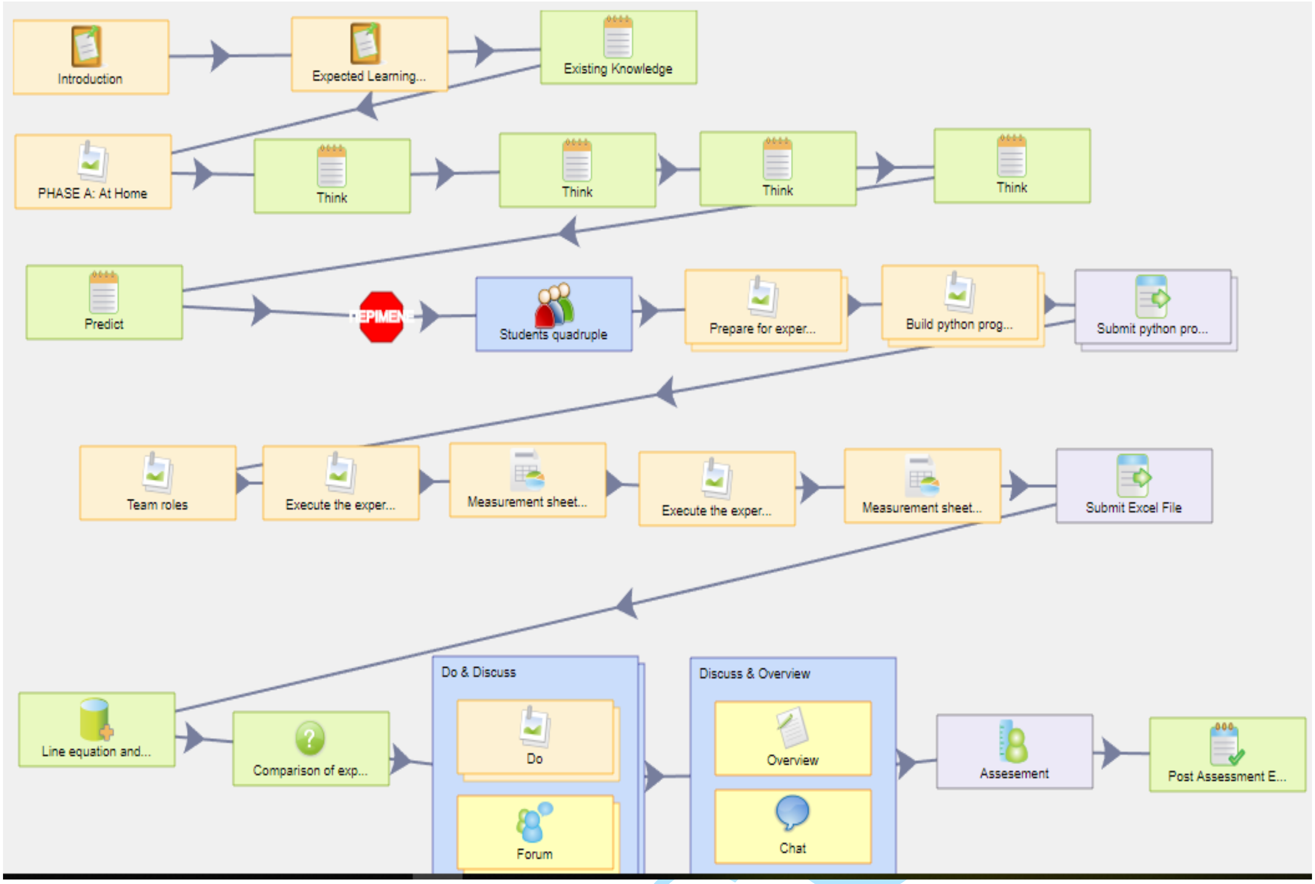

Figure 1. The general design of the LAMS course

4.1 Pre-class activities

The first part of the lesson was digital and concerned the distance study of students at home before school teaching time. At this stage, students were encouraged to study at home, at their own pace and time, and this included: **a)** an introductory page **b)** a page with the objectives and the expected results of the lesson, **c)** audiovisual material: video presentations of the gravitational acceleration phenomenon, **d)** a videotaped experiment of gravitational acceleration which describes the theory analytically and with realistic examples; **e)** the corresponding pages of the school digital book for study; and **f)** optional external material for further study.

We uploaded all videos in the Edpuzzle platform for further processing and added questions relevant with the content of video. The students had to answer the questions in order for the video to go ahead. In this way, we checked who watched the video and if they understood it. The lesson was published at URL http://lamscommunity.org/lamscentral/sequence?seq_id=2264829 with title "Gravitational Acceleration - LegoEV3_Python - PROBOT".

4.2 Activities within the classroom

The second phase of FC lesson took place in the classroom by means of LAMS platform. Students were already divided into groups of five. The planned classroom activities were as follows:

- Talk about videos they viewed at home - Checking pre-requisite knowledge with questions. (10 ')
- Activity -Engineering. The students built in groups a Lego Mindstorms EV3 robot drop tower of a ball equipped with suitable sensors. Instructions were downloaded from LAMS platform. (60 ')
- Activity –Programming. The students programmed a Lego robot in Python language for calculating (g) and submitted it in LAMS platform. (90 ')
- Activity –Presenting. Each group presented its experiment to the whole class, while the others groups commented each solution. (20 ')

Since it was the first time that the lesson with FC model was tested, we devoted 10 minutes to discuss with students about the video lectures they had seen at home. They all liked the process and described it as original and entertaining. The queries about the videos were less than expected. The Lego constructions with the programming excited students because they did something practical. Students had the ability to move free in space and cooperated harmoniously to succeed the best result as a group. Often, the groups had been interacting with each other by getting ideas, controlling their results, helping each other and comparing their creations and their findings. The presentations of the students were very good and all the comments very interesting. The

best Lego construction has remained in the class as surveillance material for the next attempts of FC.
We should note that instant messaging was also enabled in LAMS so that students can exchange ideas, opinions and whatever they want, even when accessing from home. In addition, there was one "I speak with the teacher" support activity, where students could submit their queries or opinions.

4.3 Activities after the lesson

The penultimate activity concerned the optional completion of a worksheet. This activity was completed at home and provided an opportunity for revision and further study. The last activity included a short evaluation sheet which was completed digitally. The lesson ended with a congratulatory announcement.

5. METHODOLOGY

The present action research was conducted within the framework of the DREAM Erasmus+ KA201 project in which the three authors take part. Initially we asked the Physics teachers of our school to choose a subject of Physics for the period of research (2nd quarter 2016-2017). Based on their responses, we chose to teach the gravitational acceleration concept with the FC methodology. Two experimental classes of 49 students of the 10th grade of 1st General Lyceum of Aigio took part in the research. Gravitational acceleration concept was also taught in another 2 control classes by the conventional method of teaching.
At first, we searched and found relative videos of duration smaller than 10 minutes. Each video was shared with the students using the LAMS digital platform through which students were led to another video hosting platform, Edpuzzle. Students were watching videos and were answering questions that we had incorporated into videos to make the process more interactive and to ensure active viewing. Via the platform Edpuzzle, we got feedback if each student saw each video, how many times they saw it and in which questions they answered correctly.
In the second phase, STEM robotics activities were conducted in the classroom. On the third and last phase of FC, after class, FC process was completed with a written test of the students on the cognitive aims of the lesson. In February 2017, the students of both the experimental and control classes responded in the classroom to a brief examination. The test was created in collaboration with the Physics teachers. The grading was all done by the Physics teachers. The results of the students were: Experimental classes: Average = 16.8 / 20, Control classes: Average = 15.2 / 20.

During the survey, the teacher activities and impressions, as well as any problems coming from the application of FC methodology were recorded through systematic observation. Finally, the views of the students of the target group and of the two candidates FC Physics teachers attending our courses were also recorded.

6. DISCUSSION & CONCLUSSIONS

From this action research we concluded that FC can be implemented fairly easily by each teacher with basic ICT skills, provided that they are willing to change the teaching style and to devote time for the creation or discovery of educational content. As a prerequisite for the success of the FC method, parental agreement and appropriate student education in the new method are necessary.
The benefits of the FC in our classes were particularly important and summarized in better management of teaching time leading to a better understanding of the subject, increased student participation and improved learning outcomes. Various technical difficulties emerged but were solved with good mood and flexibility in design and implementation. The answers of students in the feedback questionnaire revealed that 80% of them felt that the video lessons and the STEM activities inside the class helped them to better understand the subject and that they prefer learning with this model to the traditional one.
As to whether the learning outcomes were affected by the FC, this was answered by the comparison of the experimental classes versus the control classes in rating, which shows that the experimental classes outperformed the control classes in test.
As shown by the students' feedback on the feedback questionnaire, the majority of students were pleased with the implementation of the FC model and they wanted us to continue applying and extending it to other lessons. They evaluated positively the questions contained in the video tutorials and determined that the maximum duration of an effective video lesson should be up to five (5) minutes.
By supervising the course in LAMS, we were able to observe that students' interaction with the teaching material (presentation, video, book and external material) varied from student to student and was different between different types of digital learning objects. The lesser engagement concerned the optional material for further information followed by the study of the extract of the book. The video presentation and experimental videos have the highest viewing rate (both in time and in revision), which confirms the preference of students in contemporary, interesting, interactive, audio-visual material. Especially, the experimental video cultivates

scientific thinking and teaches the concepts and phenomena in a better way. According to the bibliography [BOW11] students prefer their teacher to talk in the digital material they are studying at home. This is going to be implemented in the next versions of video lessons.

In conclusion, the laboratory nature of Physics courses can be enriched on the basis of blended learning and STEM. Students can watch the experiment at home before going to the classroom or to the school lab to perform it. Thus the classroom or lab acquires more interest, becomes a space of energy, research and creation action. Physical science lessons can be based, at least in some teaching units, on the FC model.

The teacher should carefully plan the three stages of preparation and application: before class, in class and after class. One concern that we have to mention is the change of the role of the teacher. The FC expands their role outside the classroom, as communication with students through the digital platform becomes more frequent and more complex.

REFERENCES

[BV13] **Bishop J. L., Verleger M. A. -** *The flipped classroom: A survey of the research.* In: ASEE National Conference Proceedings, Atlanta, GA, 2013.

[BOW11] **Bergmann J., Overmyer J., Wilie B. -** *Flipped Class The: Myths Vs. Reality.* Retrieved from: http://www.thedailyriff.com/articles/the-flipped-class-conversation-689.php, 2011.

[Dal03] **Dalziel J. -** *Implementing Learning Design: The Learning Activity Management System (LAMS)*, Sydney: E-learning Center of Excellence (MELCOE), Macquarie University. Retrieved from www.melcoe.mq.edu.au/documents/ASCILITE2003%20Dalziel%20Final.pdf, 2003.

[EIL14] **Estes M. D., Ingram R., Liu J. C. -** *A review of flipped classroom research, practice, and technologies.* International HETL Review, Volume 4, Article 7, Retrieved from: https://www.hetl.org/feature-articles/a-review-of-flipped- classroom-research-practice-and-technologies, 2014.

[Gra14] **Grammatikopoulou A. -** *Creating a hybrid model on distance teaching mathematics in secondary schools.* (Bachelor's thesis). EAP, Patras, 2014.

[KB13] **Kandrudi M., Bratitsis Th. -** *Curved Teaching as a collaborative learning approach: Bibliographic review.* In: Proceedings of the 3rd Pan-Hellenic Conference "Integration of ICT in the Educational Process" of the Greek Scientific Association of ICT in Education, Department of Digital Systems, University of Piraeus, Piraeus, 10-12 May 2013.

[P+10] **Papadakis S., Paschalis G., Rossiou E., Dvoros N. -** *Education and Practice with the Free Open Internet Learning Management System (LAMS)*, 2nd Pan-Hellenic Educational Congress of Imathia, Veroia - Naoussa, 23-25 April 2010.

[RRS13] **Roehl A., Reddy S. L., Shannon G. J. -** *The flipped classroom: An opportunity to engage millennial students through active learning strategies.* Journal of Family and Consumer Sciences, 105 (2), 44-49, 2013.