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APPLICATION OF THE FLIPPED CLASSROOM MODEL TO STIMULATE UNIVERSITY STUDENTS' LEARNING WITH ONLINE EDUCATION

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Abstract

This work sets out the results of a teaching innovation project applying the flipped classroom model in the Knowledge of Mathematics module on a bachelor's degree in primary education over two consecutive years at a university that exclusively uses online teaching. This model is used with the aim of stimulating the students' working methods and improve their intrinsic motivation.

The research evaluates the impact of the flipped classroom on academic performance in the subject and collects information on student satisfaction with the development of the experiment. This is a pioneering study as it analyses learning outcomes with mathematical content in university-level classes delivered online synchronously on a permanent basis and not owing to exceptional circumstances such as the Covid-19 pandemic.

To do this, specific videos were developed, which students had to watch, with various practical exercises embedded in them to be done before classes. The marks from these exercises along with the final grades for the course are considered to assess the learning outcomes throughout the semester.

The results obtained were clearly positive both in performance and in terms of students' motivation and awareness of their own learning process, as well as the contribution of this proposal to improving their teaching–learning process, essentially through greater student involvement in and commitment to the subject.

Keywords **–** Flipped classroom, Performance factors, Educational technology, Higher education, Motivation, Videos.

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1. Introduction

University tutoring is one of the key activities in the process of integrating universities into the common European space (Martínez-Clares, Pérez-Cusó, González-Morga, González-Lorente & Martínez-Juárez, 2020), as with the reform of the Bologna Plan it has, along with guidance, become a clear indicator of the quality of university institutions. But without questioning its importance and necessity, there are a series of significant weaknesses in the way it is usually formulated that can lead to students becoming demotivated and a lack of involvement by teachers, who see it as a mere formality (Pérez & Martínez, 2015).

In the university where this research was carried out, which uses wholly online teaching, the tutoring process has two components. On the one hand the student has a tutor (a non-academic figure) who provides guidance throughout all of the educational process on a continuous basis, adding value for students. This reasons for this figure, who helps personalise university teaching, are the setting in which teaching is not done in person, which means that the student is more isolated than in the context of in-person university teaching (Kara, Erdoğdu, Kokoç & Cagiltay, 2019), and the characteristics of the students who pursue online studies who on average are in their thirties and combine their studies with professional and personal life.

In addition, at the academic level, the module teacher dedicates a given number of classes (synchronous online sessions) to resolving group or individual doubts, and revising content or doing practical exercises (depending on the judgement of the teacher). However, attendance of these revision sessions is generally low and so the teacher's effort in preparing materials goes to waste.

It is for this reason that we have identified a need to dynamize these revision sessions and offer a suitable and real response to the needs of all of the students. Consequently, a teaching innovation project based on the flipped classroom model to help to focus all of the teaching work on the students' learning was implemented.

Flipped learning (flipped classroom) is an active educational model centered on the inclusion of technology and virtual teaching–learning, which facilitates adapted teaching, offers instant feedback and supports each student's learning (Bergmann & Sams, 2012).

Wesley Baker first introduced the concept of "flipping the classroom" in a paper he presented in 2000 at the 11th international Conference on College Teaching and Learning in Florida (Baker, 2000) where he considered the use of web-based learning management tools. In the same year, Lage and her collaborators coined the term flipped classroom, implementing a model called the inverted classroom where students watched lectures before class and spent the time in class working in small groups and resolving doubts (Lage, Platt & Treglia 2000). However, it was not until 2007 that Jonathan Bergmann and Aaron Sams consolidated the concept of flipping learning (Bergmann & Sams, 2012) when they decided to record their classes and send them to students who could not attend in person. These videos were so successful that they realised that they could use the time in class for other activities.

However, the flipped classroom does not just involve inverting the order of activities, nor is it a synonym for using online videos to replace the teacher (Martín-Rodríguez, & Santiago-Campión, 2016); it is an educational model that seeks a more flexible response that is better adapted to the real needs and interests of students and to social changes that occur (Tourón, Santiago & Díez, 2014). Its correct implementation requires: a setting that students can easily access, which allows them to choose when and where to learn; a change towards a model of student-focussed learning in which time in class is spent covering previously selected concepts in greater depth; and teachers who know how to guide and evaluate the learning process (Delozier & Rhodes, 2016; Rotellar & Cain, 2016), as they must decide which concepts must be taught directly in class and which will be explored individually (Moreno-Guerrero, Soler-Costa, Marín-Marín & López-Belmonte, 2021).

Although flipped learning is used both at compulsory levels and in higher education, its effectiveness has mainly been analysed in the university sector (Zainuddin & Perera, 2019), possibly because of the opportunity it offers students to be the central figures in the learning process (Galindo-Domínguez & Bezanilla, 2019). Consequently, there are numerous recent relevant works, such as those done by Aguilera, Manzano, Martínez, Lozano and Casiano (2017), Alebrahim and Ku (2020), Prieto, Díaz, Lara, Monserrat, Sanvicen, Santiago et al. (2018), Romero-García, de Paz-Lugo, Buzón-García and Navarro-Asencio (2021), Tse, Choi and Tang (2019), Valero, Martinez, Pozo and Planas (2019), Zheng and Zhang (2020); Zheng, Bhagat, Zhen and Zhang (2020) and Zheng, Chang, Lin and Zhang (2021). This is especially notable since the suspension of in-person classes owing to the Covid-19 pandemic and the shift to online learning in many centres (Campos-Mesa, Castañeda-Vázquez, Del Castillo-Andrés & González-Campos, 2022; Clark, Kaw,

Lou & Scott, 2022; Oliván-Blázquez, Aguilar-Latorre, Gascón-Santos, Gómez-Poyato, Valero-Errazu, Magallón-Botaya et al., 2022).

These works agree that the principal advantages of using the flipped classroom model include an increase in student motivation, development of the teamwork competence, an increase in self-regulation and, by extension, improved academic results or, at least, improved academic performance in contrast with the traditional methodology. Experimental studies into the flipped classroom when teaching science content have found that the learning results are positive when compared with the more traditional model (González, Jeong, Cañada & Gallego, 2017; Torrecilla, 2018; Torrecilla & García, 2020).

Unsatisfactory results are also sometimes found with this model as result of technical problems or problems with resources in its implementation or execution (Cabi, 2018; He, Holton, Gu, Warschauer & Farkas, 2019; Pence, Franzen & Kim, 2021), which increase students' resistance to the implementation of the flipped classroom. Zainuddin and Perera (2019) note that the use of the flipped classroom model fosters active learning by students. For it to be effective, changes are required not only in the role of the teacher, who must act as a guide (Martín-Rodríguez & Santiago-Campión, 2016) increasing the interaction between students and teachers during the class (Van Alten et al., 2019), but also in the students, who have an increased requirement for independent work and responsibility for the teaching-earning process (Sacristán San Cristóbal, Martín, Navarro-Asensio & Tourón-Figueroa, 2017; Tourón et al., 2014).

Although this type of learning is commonly used in classes with in-person teaching, it is a significant innovation in online teaching, which is characteristic of our university. Some authors apply this model in online settings (Chiou & Shih, 2015; Jeong, González-Gómez & Yllana Prieto, 2020; Schwarzenberg, Navon & Pérez-Sanagustín, 2019) but few apply it in a fully online setting, and there are even fewer who do so in synchronous online classes: Romero-García et al. (2021) have applied it in a master's degree in teacher training and Sacristán San Cristóbal et al. (2017) in the study of a topic with students from a bachelor's degree in early years teaching, on both occasions in modules from the field of the social sciences and in both cases with positive results in improving students' learning.

In this context, some of the advantages of the flipped classroom, such as enabling access to content at any time and place thanks to the use of technology (Vidal, Rivera, Nolla, Morales & Vialart, 2016) and its flexibility as it works with online material (Tourón & Santiago, 2015), can be diluted as the students habitually construct their knowledge in virtual settings, and the students who choose this type of study instead of in-person teaching are generally thought to have a higher level of digital competence (prior or acquired).

The aim of this work is, by implementing the flipped classroom model in the revision classes in the Knowledge of Maths in Primary Education module at a university with exclusively online teaching, to analyse students' perception of and satisfaction with the implementation of the experiment and the impact of flipped learning on the students' academic performance.

This aim includes the following specific objectives:

a) To compile content of educational interest for use in the revision sessions as necessary materials in the flipped classroom.

b) To dynamize the revision sessions and for this to be reflected in an improvement in the academic results in the module.

c) To boost students' acquisition of habits relating to autonomous learning and strengthening the reasoning competences necessary to pass the module.

d) To carry out formative assessment of these sessions with the aim of incentivising the students.

2. Methodology

2.1. Description of the Experiment and Working Procedure

Degree students access a virtual work platform and do the activities or work through the content asynchronously. However, in the university's programme, weekly classes are set, which students can attend synchronously throughout the term using Adobe Connect software and where they can make contact with other classmates and receive direct feedback from their teacher. In this module, there are 19 sessions of 120 minutes each, including 1 for presenting the module and 4 specific sessions for revision and resolving doubts.

The proposed working dynamic involves students consulting the content provided by the teacher before the face-to-face class and doing a series of exercises before each revision session such as watching videos, studying information and solving exercises. Before attending each revision session, the teacher reviews which students have watched the videos and their marks from the questions embedded in the videos, giving the teacher an overview, of which questions the students found most difficult. The revision sessions comprise a plenary where the practical exercises done in advance by the students are corrected and doubts are resolved. Their application in the innovation project is aimed at finding a balance between the students' needs detected when they complete each block of content, so that the teacher can work on each student's weaknesses before continuing with a new topic.

There was a series of stages before launching and implementing this project:

- An initial phase where the content to be worked on in the activities was compiled along with the proposed exercises to solve.
- A planning phase where videos were produced and made available to the students to be watched in the weeks before each revision session. Three videos were prepared for each revision session, giving a total of 12 videos (table 1).

The videos, which have a mean duration of between 10 and 11 minutes, were made using the Screencast-O-Matic free tool. Using this program, the PowerPoint presentation and the teacher's voice and image were recorded with the webcam. The aim of this was to give an increased proximity to all of the users who watch the video. The video files were exported to MP4 format and uploaded to the Edpuzzle free application. This tool makes it possible to edit videos to adapt them to the needs of their users. Each resulting video included:

- Voice clips
- Notes and explanatory comments
- And the evaluation questionnaires at the end of each video (which were either single-response questions or multiple choice).

Students can access the videos in the Edpuzzle tool using a password and watch them as often as they need. It should be noted that the videos are open to all of the students taking the module, regardless of whether they took part in the revision sessions.

- The implementation phase with the opening of a forum on the virtual campus for the module where the students can express any doubts while doing the exercises or after the class to clarify the concepts. In addition, revision sessions were provided, distributed throughout the module, where the topics covered in the programme were grouped for revision.
- The evaluation and assessment of the experiment phase, which is shown in this work and where the impact of the flipped classroom on learning is analysed along with the evaluation of the students' satisfaction with this working method. To do so, the number of views of the uploaded videos, the marks students obtained in the activities provided and the comparison between the final grade for the module of the students who took part in this experiment compared with the

students who did not take part are used as indicators to establish how much benefit the students derived from this method of working.

Revision sessions	Content	Videos
Revision session 1	Natural numbers, integer and rational numbers	Videos 1, 2 and 3
Revision session 2	Real and imaginary numbers, measurements and proportionality	Videos 4, 5 and 6
Revision session 3	Plane geometry and space	Videos 7, 8 and 9
Revision session 4	Functions, statistics and probability	Videos 10, 11 and 12

Table 1. Distribution of the revision session by content

2.2. Participants

The experiment was carried out over two consecutive academic years in the mathematics module (2020-21 and 2021-22 academic years). Of the total number of students enrolled in the mathematics module (N = 223), 125 participated actively in his experiment (56.0% of the total), 88.1% were female and the remaining 11.9% male (110 women and 15 men).

A questionnaire was developed using Google Forms so that the students could anonymously evaluate the experience. The survey was completed by 109 students (87.3% of the participants). It comprised 8 questions using a 5-point Likert-type scale (Likert, 1932) (the values were: 1=strongly disagree; 2 = disagree; 3 = neither agree nor disagree, 4 = agree; and 5 = strongly agree) and a final space for free comments and reflections by the students. The questions (Q) used, adapted from Dafonte-Gómez, García-Crespo and & Ramahí-García (2018) were as follows:

Q1-Does this experience help you stay up to date with the module?

Q2-Do you think it encourages interaction with the teacher?

Q3-Are the tutoring sessions more interesting for you?

Q4-Do you think it offers you more opportunities to resolve doubts?

Q5-Do you think that this methodology is positive for your learning?

Q6-Do you think you learn more with this methodology than with the conventional one?

Q7-Do you prefer this method to the conventional one?

Q8-Do you think that the material supplied by the teacher is appropriate?

The descriptors for each variable and the correlations between them were analysed with the SPSS v.22 statistics program using the Pearson correlation. Pearson correlation method is the most common method to use for numerical variables; it assigns a value between −1 and 1, where 0 is no correlation, 1 is total positive correlation, and −1 is total negative correlation. A positive correlation signifies that if variable A goes up, then B will also go up, whereas if the value of the correlation is negative, then if A increases, B decreases (Boslaugh & Watters, 2008).

3. Analysis and Results

The Cronbach's alpha value for the questionnaire used after the experiment gave a coefficient of .83, which reflects a high level of reliability as the value obtained was greater than .80 (De Vellis, 2003).

The evaluations corresponding with a high level of agreement (4 and 5 points on the questionnaire) have been considered for interpreting the results. Accordingly, more than 95% of the opinions recorded, noted that the flipped revision sessions helped students keep up with the module (95.4%), they favoured interaction with the teacher (96.8%), they offered more opportunities to resolve doubts (96.6%), it was a positive methodology for learning (98.8%), the students learned more with it than with the conventional methodology (97.8%) and they preferred it to the traditional methodology (98.8%).

Of the respondents, 87.7% said that they found the classes more interesting and 92.3% reported that the material supplied by the teacher was appropriate.

The mean for each of the responses was more than 4 points, and the median of 5 for all of the questions reflected the large number of 5-point evaluations received. The standard deviation is low in all of the questions, as Table 2 shows.

Parameters	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**
Mean	4.70	4.65	4.37	4.71	4.92	4.68	4.68	4.30
Median	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Standard deviation	.56	.68	.88	.58	.41	.65	.65	.97

Table 2. Mean, median and standard deviation of the questionnaire administered

All of the correlation coefficients between variables calculated are positive, with the largest positive correlations being between: Q6 (do you think you learn more with this methodology than with the conventional one?) and Q7 (do you prefer this method to the conventional one?); Q7 (do you prefer this method to the conventional one?) and Q8 (do you think that the material supplied by the teacher is appropriate?); and Q6 (do you think you learn more with this methodology than with the conventional one?) and Q8 (do you think that the material supplied by the teacher is appropriate?).

Table 3 shows the relationship between the first two, Q6 and Q7, as they display a Pearson correlation coefficient greater than .75, which reflects a considerable positive correlation (Hernández-Sampieri, Fernández-Collado & Baptista-Lucio, 2010).

		Q6	**Q7**
Q6	Pearson correlation	1	.969**
	Sig. (2-sided)		.000
	N	125	125
Q7	Pearson correlation	.969**	1
	Sig. (2-sided)		.000
	N	125	125

**The correlation is significant at the .01 level (2-tailed)

Table 3. Pearson correlation indexes

The analysis of the information provided by the students in their comments after the application of the flipped classroom model in the revision sessions corroborates the perception of the flipped focus being positive.

The qualitative results revealed opinions that can be divided into 5 broad groups of topics: (1) students' motivation; (2) help passing the module; (3) interaction with the teacher; (4) valuation of the videos provided; and (5) student interest and involvement. Some of their textual comments are set out below:

> *"This methodology made it easier for me to keep up to date with the content and it has motivated me when doing the activities"* (Comment 110).
>
> *"I have enjoyed working with this methodology because it has helped me internalise the mathematical knowledge. In fact, it has been decisive for understanding the problems, being motivated and gaining confidence"* (Comment 23).
>
> *"The revision videos are well spread out over the length of the module. Their length and content is appropriate and concise, and they summarise very well the principal concepts of the topic, which facilitates their assimilation by the student"* (Comment 29).

> *"I like this concept of teaching, as, although there is an initial explanation in the videos, the teachers can focus on some parts of the syllabus once they see what problems are most common. This way saves the time that would be spent explaining concepts that are easy to understand"* (Comment 30).
>
> *"Doing the revision work helps you practice and keep up with the module. In addition, it is a practical method that tests you and then you can interact with the teacher in class"* (Comment 47).
>
> *"Throughout the term you do more work, but it is compensated when you study, because we have been so involved since the start with the module that now all we have to do is go back over it and you do not have to learn anything new"* (Comment 50).

There was no unfavourable opinion about this, apart from some regarding the limitations of the use of Edpuzzle:

> *"It would be good not to have to change platform to see the videos and do the exercises"* (Comment 4).
>
> *"It would be good to have an app with more options. Edpuzzle is limited"* (Comment 153).

However, including the videos and the proposed exercises on the university's own online platform would be simple, and using proprietary tools could facilitate the application of the flipped model.

As Table 4 shows, the mean grade obtained by the students when doing the exercises from the videos was high in the first revision session, which covered topics with a lower level of difficulty, and was lower towards the end of the module as this is the more abstract part of the syllabus and includes more complex topics such as statistics and probability. The mean grade for the activities done by the students answering the problems set in the videos was 9.08 with a standard deviation of .89.

Parameter	Revision session 1 (videos 1-3)	Revision session 2 (videos 4-6)	Revision session 3 (videos 7-9)	Revision session 4 (videos 10-12)
Mean	9.40	9.09	9.18	8.69
Standard deviation	.79	.81	1.15	.84

Table 4. Mean grades for each revision session

Table 5 shows the total number of views of each video uploaded, independently of when they were viewed, along with the percentage of the total duration of each video viewed. As can be seen, in both cases the data stabilise from the work with the videos of the second revision session.

Views of the videos were high with 72.6% of students revising the videos at some point throughout the module. This is very important in the module in question as it enables students to keep up with the content (as the students themselves observed in the evaluation in the questionnaire). Information on the number of video views can become a relevant source of data to quantify the effect of video usage. Some trends have been observed: The number of views decreases throughout the sessions when the topics become more abstract and complex. However, the students who see them do so in greater depth, as can be seen by increasing the % of the total viewed.

Finally, the mean grade that the students who participated in the process obtained in the final exam for the module was 9.31 with a standard deviation of .071, while for the students who did not participate, the mean grade was 8.48 with a standard deviation of 1.08 (it is worth recalling that this second group of students also had access to the videos to be able to practice for the exam even though they did not do the exercises for the revision sessions). In previous years, following a traditional work methodology, the mean grades obtained in the subject were lower, 7.111.44 and 7.251.46, respectively.

Videos	Number of views	% of the total viewed
Video 1	210	95.75
Video 2	214	96.40
Video 3	204	97.25
Video 4	178	97.45
Video 5	172	99.78
Video 6	172	98.38
Video 7	160	98.71
Video 8	164	99.78
Video 9	162	98.27
Video 10	152	98.75
Video 11	154	99.06
Video 12	156	98.83

Table 5. Total number of views of each videos used in the module and % of duration viewed in each of them

4. Discussion and Conclusions

The arguments in favour of this methodology note the existence of more personalised, flexible, attractive and active learning, in which learners are more responsible for their own learning, fostering students' autonomy (Mengual, López, Fuentes & Pozo, 2020; Zainuddin & Perera, 2019).

The results of the work show a high level of student satisfaction with the methodology applied, as they consider that the flipped classroom is positive for their learning because it offers them more opportunities to resolve doubts and interact with the teacher. This is important in online learning where students can feel less protected than with in-person teaching and it is in accordance with prior studies (Basso-Aránguiz, Bravo-Molina, Castro-Riquelme & Moraga-Contreras, 2018), which found that one of the advantages of the flipped classroom is that it allows a closer, more reflexive and more critical student-teacher interrelation.

Indeed, the students prefer it to the traditional methodology, with questions Q6 (do you think you learn more with this methodology than with the conventional one?) and Q7 (do you prefer this method to the conventional one?) showing the highest positive correlation.

As found in previous works on the flipped classroom (Jeong et al., 2020; Valero et al., 2019; Zheng et al., 2020; Zheng et al., 2021), the students felt more motivated because they found the classes more interesting. However, it has not been possible to confirm that there is an increase in self-regulation in the students' learning with this practice, as students need to have strategies to be able to manage the activities to be done in the online teaching-learning process. They must be capable of self-regulating their metacognition and of adapting to developing situations, determining the time to be spent on the virtual modality (Meza-López, Torres-Velandia & Lara-Ruiz, 2016), as well as self-regulation in the process of instruction and planning of objectives that enables them to combine working, academic, and personal life (Means, Toyama, Murphy, Bakia & Jones, 2009).

In agreement with studies by earlier authors in which the flipped classroom method was applied (Alebrahim & Ku, 2020; Campos-Mesa, 2022; Zheng et al., 2020; Zhu, Lian & Engström, 2020), what has been verified here is an improvement in academic performance on the module, in this case of almost one extra point on a ten-point scale when comparing the academic results obtained in the module's final exam between the students who participated in this experiment and those who did not. This can be attributed to an increase in hours dedicated to learning with increased daily effort and attention (Salcines-Talledo, Cifrián-Bemposta, González-Fernández & Viguri-Fuente, 2020), to the commitment and central role of the students (Miragall & García-Soriano, 2016) and to the fact that the teacher prepared videos explaining

the topic and providing additional material for study, helping to involve students fully in the learning process.

In fact, the students very positively valued the material provided by the teacher as support for the learning they construct, to keep up with the module and revise content before the exam, because it helps them complete and correct more practical activities. This is demonstrated both in the high number of views of the videos, with the percentage of students who view the videos at some stage in the module easily exceeding those who do not, and in the high mean grade obtained by the students who participate in the experiment in solving the exercises proposed after each video. And even more if the yields obtained are compared with the qualifications in the subject in previous years.

The results of this innovation project add to the growing body of research into the application of the flipped classroom, with the distinguishing feature that it has been applied with students who pursue their studies wholly online in normal circumstances and not as a result of the circumstances deriving from the recent Covid-19 pandemic. This work is the first to analyse learning of mathematics content by students from a bachelor's degree in primary education using entirely online teaching based on the flipped classroom model.

The limitations of this work include the fact that the sample might not be representative of the university population engaged in online studies in general, although the level of agreement of the statistical test practised in the results is relevant.

It would be interesting to replicate the study in other theoretical-practical modules from the same degree, as well as in scientific modules from other bachelor's or master's programmes at this e-learning university to verify the results obtained.

The flipped model seems to be a highly suitable model to apply in these studies, as it is an appropriate methodology for dynamising the module and ensuring active learning by students, which favours more effective learning (Zainuddin & Perera, 2019), something undoubtedly promoted by the inversion of roles by the teacher and student in order to carry out the learning process and the considerable interaction between them both (Aguilera et al., 2017; Van Alten, Phielix, Janssen & Kester, 2019), which helps to respond to students' individual differences (Tse et al., 2019).

As García-Aretio (2018) observes, the flipped classroom modality can be integrated as a model within blended-learning. We move, therefore, to the third generation of the online studies model (Gros-Salvat, 2011), centred on flexibility and the use of any methodology that favours online studies, where students are aware of their own learning and of how to achieve it.

In summary, the already existing virtual learning environment should be combined with and complement the flipped model, which as we have seen, was highly suited to meeting the learning needs of our students.

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