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Learning of paediatric dentistry with the flipped classroom model

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Abstract

Introduction: The flipped classroom (FC) is a pedagogical model that can be very useful in obtaining a dentistry degree. The main objective of this study was to compare learning between student groups introducing FC in the area of paediatric dentistry at the Complutense University of Madrid in 2019.

Materials and Methods: In this study, 76 students enrolled for the first time in the Pediatric Dentistry programme and completed a questionnaire (pre-Q) regarding specific theoretical knowledge about pulpotomies. Subsequently, they were divided into two groups: group A, which had free access before the class to an explanatory video about the indications and techniques of pulpotomy and group B, which viewed the same video only one time in class. After that, all students completed the same questionnaire (post-Q) again and a survey on the degree of satisfaction about the teaching method.

Results: The differences in score between the post-Q and pre-Q in group A had a mean (SD) value of 3.5 (2.4) and in group B, a mean (SD) of 2.5 (2.2), with a p value of .07. In questions 3, 5 and 8, learning was greater in the experimental group ($p = .007$, $p = .02$ and $p = .001$, respectively). For 74.4% of the students in group A, accessing the video previous to the class was a very useful tool.

Conclusions: These results suggest that implementing FC in paediatric dentistry classes help students to acquire more theoretical knowledge, which is necessary before practical teaching.

KEYWORDS
dental education, flipped classroom, paediatric dentistry, teaching methods

1 | INTRODUCTION

The teaching methodology in dentistry is undergoing great changes. It is necessary for students to develop critical thinking and know how to solve problems. Students must acquire the ability to self-direct information search strategies, which are necessary to correctly develop their professional practice.[1,2] A relatively recent learning strategy that helps students improve these aspects is the so-called flipped classroom (FC). According to Abeysekera and Dawson, FC is defined as a set of pedagogical approaches that (a) move most information-transmission teaching out of the classroom setting, (b) use class time for learning activities that are

active and social and (c) require students to complete pre- or post-class activities to fully benefit from in-class work[3] It was popularised by the work of Jonathan Bergmann and Aaron Sams, two chemistry teachers who, in 2007, began uploading their lessons to YouTube. The FC is a pedagogical model based on reversing the traditional structure of face-to-face classes with the use of information and communication technologies. The teacher produces or selects digital material (audiovisual presentations, videos, infographics, websites, etc.,) where predetermined contents of the subject are exposed and different types of activities are carried out.[4]

Flipped classroom is a more student-centred teaching model; the teacher-student relationship is more personalised, and students are free to view the material provided. It also allows for deeper and more autonomous learning, helps to acquire transversal skills (i.e., problem-solving skills, team-working skills, communication), improves student motivation and encourages team learning.[5,6]

However, various authors point out that this model has aspects that can obstruct its implementation. One such aspect is the time required by the teacher to prepare the lessons in advance. In addition, the teacher must analyse if the FC is appropriate for both the content that is being taught and for the type of students at which it is aimed.[4–7] Another drawback is access to materials, since some technological support is needed and not all students have similar access to the Internet. Likewise, the arduous, continuous evaluation by the teacher and the autonomous work of the students outside and inside the classroom must be considered. All this can result in the lack of acceptance of this method by students.[5,6]

In the last two decades, FC has been introduced in different fields of dentistry. Park and Howell implemented this model for students in their second year of dental anatomy class, a subject with 36 students, using pre- and post-questionnaires. The study initially encountered resistance from teachers, but as it was established, the comments were more positive. The students considered it to be a more fun, interactive and collaborative technique than the traditional class; however, they stated one disadvantage was the requirement to be connected to Internet.[7] Shapiro et al. introduced FC to see whether the students knew how to recognise and report cases of abuse and neglect in the field of dentistry. The results were that learning improved and students rated this method positively, but never as a substitute for the teacher.[8] Bohaty et al. evaluated FC for students in their second year of dentistry in the field of paediatric dentistry, where they observed that both the perception of student learning and evaluation improved with this technique. Furthermore, the degree of satisfaction of both the students and the subject director was positive.[9] A more recent study carried out by Wan Seo et al. in the study of periodontics, uploaded videos to YouTube, and 95.7% of the students stated that watching the videos before the actual class helped them better understand the class. These authors considered YouTube to be an efficient platform to implement FC.[10]

Videos are amongst many of the tools that can be used in the FC as a support method. Videos explaining in detail or showing the performance of clinical procedures are very useful to the implementation of FC. In completing coursework towards a dental degree, it is crucial that students acquire clinical skills; therefore, it would be advantageous to apply the concept of the FC in the practical portion of the course, when students would be working with patients. The application of videos for students to acquire clinical skills was analysed by Botelho et al.[11] The explanatory videos detailing certain techniques were perceived by the students as an important learning tool with which they acquired skills that could not be obtained solely from textbooks or master classes. Further, students felt that FC better prepared them to practice with patients.[11] Wongs et al. evaluated the effectiveness of instructional videos, which should be watched before classes on local anaesthesia administration. Ninety per cent of the students believed that the videos helped them to improve clinical skills in the application of anaesthesia. A statistically significant correlation was observed between the number of video visits and the grading marks obtained in the clinical practice classes.[12]

In coursework towards the dentistry degree of the Complutense University of Madrid (UCM), the course paediatric dentistry II must train the students in the acquisition of manual skills necessary for their incorporation into clinical practices. Further, students must be able to apply these techniques in paediatric patients. Therefore, we hypothesised that if students have access to information on pulp therapies through video footage that they can review before the class as many times as is needed, their understanding and learning of the treatments will improve substantially.

Our main hypothesis was based on the fact that having explanatory videos available before the class will allow students to acquire the necessary theoretical knowledge and therefore make better use of it. Our secondary hypothesis was that viewing explanatory videos pertaining to the content of the class would be accepted by the students with a high degree of satisfaction.

The main objective of this study was to compare learning between two groups of students experiencing different teaching methods: traditional vs FC. The secondary objectives that we proposed were (a) to introduce the use of instructional videos explaining in detail the theoretical description of different techniques following an FC model in the area of paediatric dentistry, (b) to compare whether learning has occurred regardless of the teaching method used and (c) to determine the satisfaction of the students regarding the visualisation of explanatory videos of the class content.

2 | MATERIALS AND METHODS

This study was approved by the Vice-chancellor for Quality of the Complutense University of Madrid (UCM) (reference no. 177) for the 2018 to 2019 call for educational innovation projects of the UCM.

The study was carried out by professors of coursework for a degree in dentistry at the UCM. Students enrolled in the paediatric dentistry II course 2018/19 participated voluntarily, with the right to withdraw from the study at any time without adverse consequences. The students were given a brief explanation about the concept of the FC and the details of the project.

First, students were given a questionnaire with three questions that determined whether or not they had previously completed the course, as well as if they had received training in pulp treatments in temporary dentition. This allowed for the selection of students who would form the study sample. The students then filled out a questionnaire or test (pre-Q), with 10 specific questions testing knowledge about pulpotomy; this test was created by the authors based on the information provided in the video. Answers to the questions could be found in the information provided by the video (Table 1). The test was carried out at the beginning of the class, with a duration of 5 minutes. Each correct question was weighted with 1 point, with the maximum rating being 10. The student sample was randomly divided into two groups: group A (experimental) and group B (control), assigning a number to each student and using Random Number Generator Pro software, version 213 (Segobit Software inc.). For FC teaching development, the teachers made an explanatory video with theoretical and practical content about pulp treatment in temporary dentition (pulpotomy) (Figure 1). Group A students had free access to the video through the UCM virtual campus (Moodle 3.4.); they were able to view the video during the week before the class as many times as they wanted. During class time, complementary activities were carried out and any questions were resolved. Instead, Group B students received a class that included viewing the video only one time to reinforce the teacher's explanation.

One week after class, the same initial questionnaire (post-Q) was repeated to test knowledge of pulpotomy in both student groups without prior knowledge that they were going to be tested. At the same time, a survey was conducted in both groups on the degree of satisfaction concerning their participation in the project.

2.1 | Statistical analysis

The software program SPSS, version 25 (IBM Corp, Armonk, NY, United States) was used to analyse the data. Homogeneity of both student groups was verified for the number of hits of the pre-Q, and a Student *t*-test was used to analyse the average number of total correct answers on the questionnaire. Chi-squared testing was used to analyse the percentage of correct answers. To assess whether there were differences in the level of acquired knowledge between the two student groups, the Fisher exact test was used to analyse the values of each question on the pre-Q and post-Q: (a) incorrect on both tests; (b) wrong on pre-Q and correct on post-Q; (c) correct on pre-Q and incorrect on post-Q; and (d) correct on both tests. We also evaluated the difference between the student groups by using the Student *t*-test to analyse the mean increase in correct answers from pre- to post-Q test.

In order to assess the knowledge gained by the students after the class, we used the paired Student *t*-test to analyse the correct answers by comparing the results of the pre- and post-Q tests. The McNemar test was used (a) to analyse the knowledge gained by each question, (b) to analyse the questions in which there were no differences in learning between the two student groups and (c) to analyse when these differences were significant in each group.

3 | RESULTS

A total of 76 students were included in the study. Group A consisted of 39 (51.3%) students. Group B consisted of 37 (48.7%) students. The response rate in our study was of 88.6% in group A and of 88.0% in group B. Of the 100 students who were studying Pediatric Dentistry II and initially volunteered to participate in this study, 3 did not attend class the day the questionnaire for the selection of students was conducted, and 11 were discarded because they had previous knowledge of pulp treatments, leaving a total of 86 students. On the date the post-Q was performed, some students skipped class due to illness or travel and were unable to complete the study. Therefore, the final sample included 76 students: 39 students in group A and 37 in group B (Figure 2).

There were no statistically significant differences between the groups in the pre-Q (Table 1).

To analyse whether the knowledge acquired by experimental group A and control group B were different, first, the average increase in correct answers of both groups was compared. The difference in scores was 0.97 points, which was not statistically significant (p = .07) (Table 1). However, significant post-Q mean score differences were found (DATA; p = .006). When monitoring for differences in acquired knowledge between the two student groups, it was found that in questions 3, 5 and 8 (indication for procedure, identification of the instruments and type of filling material used in pulpotomies) knowledge gained was greater in the experimental group (p = .007, p = .02 and p = .001, respectively). The percentage of students who made more errors in the pre-Q and post-Q was higher in group B than in group A (question 3, 21.06% vs. 0%; question 5, 56.8% vs. 30.8%; and question 8, 35.1% vs. 7.7%). The percentage of those who gained knowledge was higher in group A than in group B (question 3, 59.0% vs. 45.9%; question 5, 30.8% vs. 8.1%; and question 8, 74.4% vs. 32.4%) (Table 2).

TABLE 1 Total correct answers in both groups in pre-Q and post-Q

Questionnaire results	Pre-Q	Post-Q	Difference
Group A	4.31 ± 1.7 (n = 42)	7.77 ± 1.8 (n = 39)	3.46 ± 2.4 (p < .001) (n = 39)
Group B	4.05 ± 1.5 (n = 44)	6.54 ± 2.54 (n = 37)	2.49 ± 2.12 (p < .001) (n = 37)
p Value	p = .838	p = .006	p = .065

Note: Means and DS (Student *t*-test).

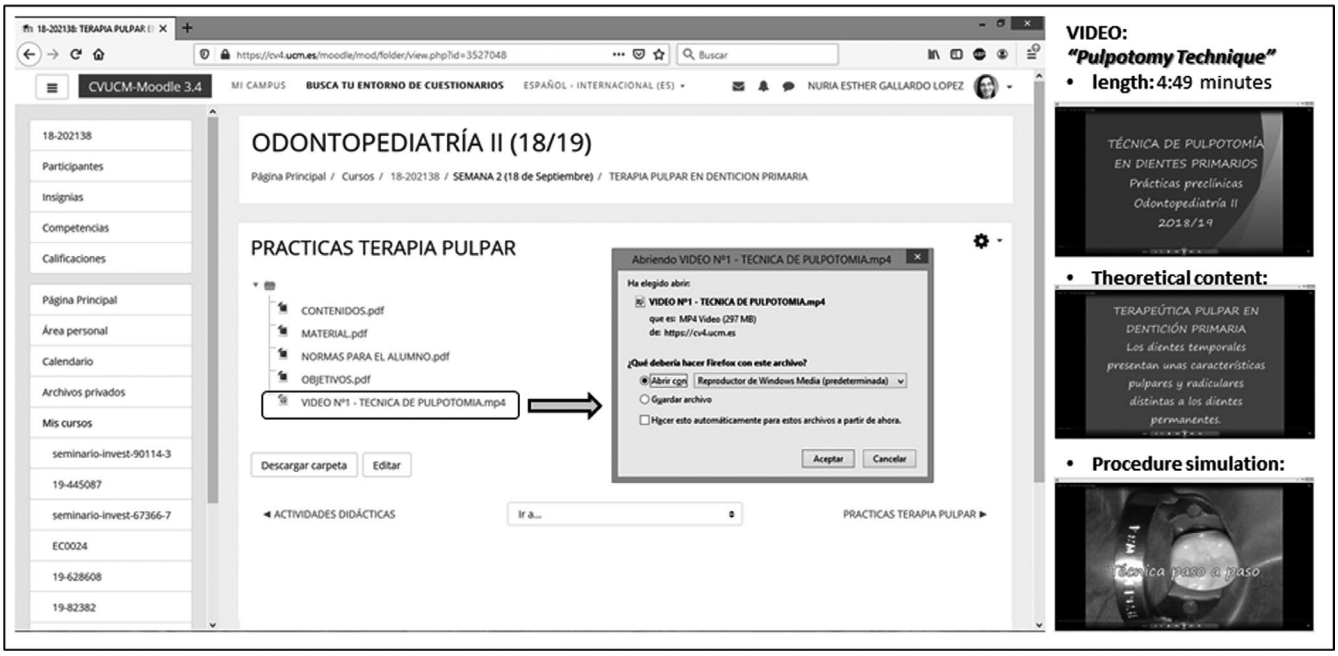

FIGURE 1 Access to the explanatory video "Pulpotomy technique" through the UCM virtual campus and examples of theoretical and practical frames

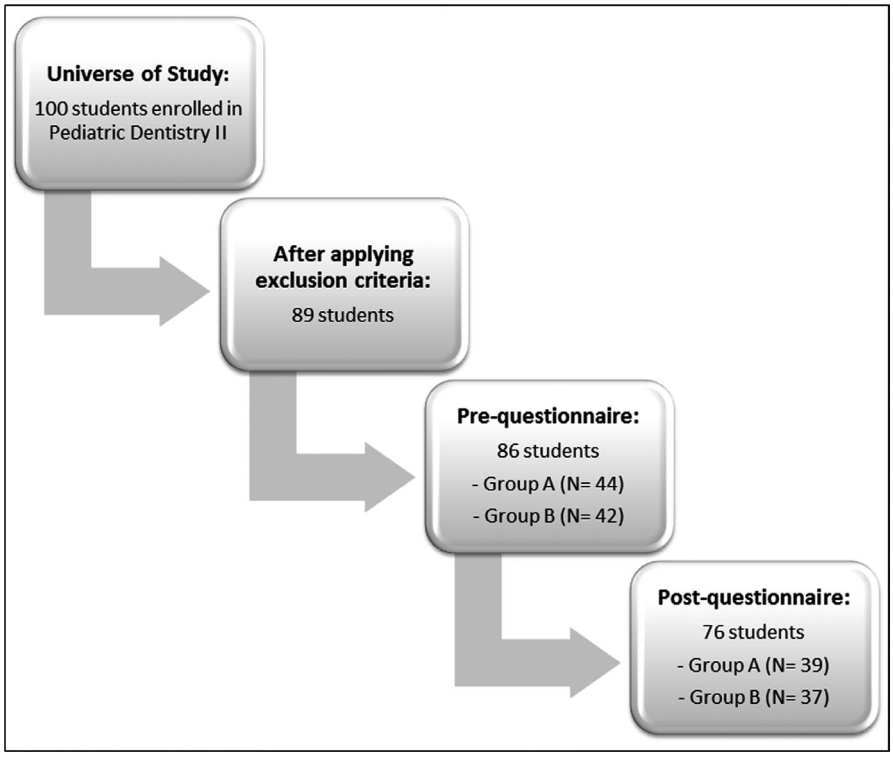

FIGURE 2 Sample of the study

When the scores of all the students were analysed, regardless of the group, it was noted that the mean (SD) score of the pre-Q was 4.1, whereas after the class, this score rose to 7.2. The results suggest that there was an associated significant increase in the mean number of correct answers in the post-Q compared with the pre-Q ($p < .001$) (Table 1).

Pre- and post-Q correct answers were also compared question by question (Table 2). In questions 3, 5 and 8, each student group was analysed independently. For all remaining questions, the total number of students was collectively analysed. The results were significant in 7 of the 10 questions (No. 1-3, 7-10). However, in the remaining questions (no. 4-6), there were no changes.

TABLE 2 Correct answers to the pulpotomy knowledge questionnaire

Knowledge questionnaire	Group A		Group B		Total sample	
	Pre-Q	Post-Q	Pre-Q	Post-Q	Pre-Q	Post-Q
1.Pulpotomy in temporary dentition consists of: a. Partial removal of the coronal pulp. b. **Complete removal of the coronal portion of the dental pulp**. c. Complete removal of the coronal pulp and partial removal of the root pulp. d. d)Complete removal of the coronal and root pulp.	14	35	12	35	26	70[1]
2.The main objective of pulpotomy in temporary teeth is to… a. Complete elimination of caries. b. **Cure the tooth and maintain its vitality**. c. Treat the tooth, eliminating its vitality. d. Reconstruct the affected tooth and maintain it until exfoliation.	15	34	15	25	30	59[1]
3.When is it recommended to do a pulpotomy in temporary dentition?[a] a. When the infection or pulp inflammation affects the entire pulp. b. Teeth with abscess or fistula but without symptoms. c. **When the infection or inflammation is limited to the coronal pulp**. d. All the previous answers are correct.	16	39[1]	15	29[1]	31	68
4.Sequence to perform a pulpotomy in temporary dentition. Point out the correct answer: a. **Anaesthesia, absolute isolation, caries elimination, cameral opening and removal of the pulp tissue**. b. Anaesthesia, elimination of caries, absolute isolation, cameral opening and removal of the pulp tissue. c. Anaesthesia, caries removal, cameral opening, absolute isolation and removal of the pulp tissue. d. Anaesthesia, isolation, cameral opening, removal of pulp tissue and elimination of caries.	38	37	39	32	77	69
5.The removal of the pulp tissue will be carried out with (indicate the wrong one): [b] a. Round bur at low speed. b. **Round bur at high speed**. c. With an excavator. d. a and c are correct.	15	19	13	6	29	25
6.The roots of the temporary teeth, in relation to the size of the crown are: a. Longer and thicker than those of permanent teeth. b. Shorter and thicker than those of permanent teeth. c. **Longer and thinner than those of permanent teeth**. d. Shorter and thinner than those of permanent teeth.	21	24	19	22	40	46
7.We will control the bleeding from the root pulp with: a. Absorbable hemostatic sponges. b. Washing with plenty of water and then drying with air. c. **With a cotton ball pressing**. d. Waiting a few minutes for the bleeding to stop.	22	35	21	34	43	69[1]
8.Once the pulpotomy is done, in this preclinical practice, what material do we use to fill the cavity?[c] a. Glass ionomer cement. b. Composite resin. c. Silver amalgam. d. **Zinc oxide eugenol cement**.	7	34[1]	14	22[2]	21	57
9.Regarding the technique of performing a pulpotomy, indicate which answer is false: a. Caries will be eliminated before coronal opening. b. After performing the pulpotomy and filling the cavity, it is recommended to place a preformed crown. c. **The removal of the pulp will be done with a lance bur at low speed or with an excavator**. d. Once hemostasis of the root pulp has been achieved, we will observe the entry into the root canals.	17	28	18	21	35	49[3]
10.The occlusal fossa of the primary molars has a thickness of dentin… a. **Greater than the permanent molars**. b. Less than the permanent molars. c. The same as the permanent molars. d. There is no dentin in the occlusal fossa.	8	18	11	16	19	34

Statistically significant differences of learning between groups (Learning of each question: Fisher exact test: a: $p = .007$; b: $p = .021$; c: $p = .001$).

Statistically significant differences between pre-Q and post-Q (Learning of each question: McNemar's test: 1: $p < .001$; 2: $p = .013$; 3: $p = .009$; 4: $p = .001$).

TABLE 3 Distribution of responses to the satisfaction questionnaire

Satisfaction Questionnaire					
Explanatory videos available before preclinical practice of paediatric dentistry		Very useful	Useful	Indifferent	Not useful
	Group A	29 (74.4%)	10 (25.6%)	0 (0%)	0 (0%)
To view the videos at the beginning of the practice and be able to solve doubts with the teacher		Very useful	Useful	Indifferent	Not Necessary
	Group B	24 (64.9%)	13 (35.1%)	0 (0%)	0 (0%)
Times you have watched the videos completely before the practice		0	1	2–3	>3
	Group A	0 (0%)	16 (41%)	21 (53.8%)	2 (5.1%)
The content of the videos helps to acquire knowledge on the subject of the practice		Totally agree	Partially agree	Disagreement	Do not know/no answer
	Group A	35 (89.7%)	4 (10.3%)	0 (0%)	0 (0%)
	Group B	30 (81.1%)	7 (18.9%)	0 (0%)	0 (0%)
	Total	65 (85.5%)	11 (14.5%)	0 (0%)	0 (0%)

When analysing the satisfaction survey (Table 3), it was noted that the students in group A stated that the video was a very useful tool, and the majority of students in group B indicated that it would have been useful if they had been able to access the video before the class.

4 | DISCUSSION

As Abeysekera and Dawson stated: "In an FC, the information-transmission component of a traditional face-to-face lecture (hereafter referred to as the "traditional lecture") is moved out of class time. In its place are active, collaborative tasks. Students prepare for class by engaging with resources that cover what would have been in a traditional lecture. After class, they follow up and consolidate their knowledge".[4] The resources used can be of various types: texts, bibliographic references, websites or instructional videos. In the teaching of dentistry, in which the practical component is essential, the use of videos has been repeatedly verified and used. For this reason, our study focused exclusively on this specific resource, based on the use of explanatory videos in which a professor delved into the theoretical explanation of clinical techniques used in paediatric dentistry.[3]

The analysis of the results of our total sample found an increase in the number of correct answers when comparing the questionnaires. These were greater in the group of students who followed the FC model, although the results were not statistically significant (p = .065). These results coincide with those obtained by Bohaty et al., who carried out a similar experiment in the paediatric dentistry course with students from a predoctoral programme. Bohaty and colleagues found an improvement in the monitoring of grades of those students who belonged to the FC group, but they do not define whether or not this improvement was statistically significant.[9]

In this sense, other authors such as Hew et al., after performing a meta-analysis of 28 comparative studies, found a significant overall effect in favour of FC compared with traditional classrooms in their use of FC for the education of health professionals (p < .001). In addition, there was no evidence of publication bias.[13] On the other hand, in studies carried out on students of nursing or biology,[14] little difference is seen between the grades of the FC modality and the traditional model.

Our study found statistically significant differences when comparing the improvement between pre-Q and post-Q scores between the student groups in 3 of the 10 questions (Table 2). We hypothesise that these differences occurred because more emphasis has been placed on these issues in the video, in much the same way question 3, referring to indications, was explained at the beginning of the video, when students tended to pay more attention. Regarding the differences in question 8 scores, we hypothesise that they may be associated with the novelty of the explained materials, taking into account that the virtual campus group was able to view the material more frequently. The results are similar to the opinions of other authors who consider that, although the FC involves students participating in self-directed active learning, in order to demonstrate significant improvement, more in-depth research is needed.[15]

It is curious to observe that question No. 5 of our work (only 33.7% of the total student sample correctly answered No. 5 in the pre-Q) did not show improvement and even decreased to 32.9% regarding the number of correct answers in the post-Q (Table 2). When we studied the pre-Q in groups, we found the following results: 15 correct answers in group A and 13 in B. After the class, in group A, the correct answers rose to 19. Although this shows little significant difference, it does indicate learning improvement when compared with those of group B, which decreased to six. The objective of the question was for the students to identify the instruments necessary for the removal of the pulp tissue during the pulpotomy. Although two possible instruments were identified in the video, in the class carried out on typodont, the students only used a spoon because it is a simulation of the dental pulp (wax). We could justify the poor results in group B to this circumstance since this group based their learning on the development of the class and was not complemented by the video preview as in group A. We could say that preclinical classes have limitations when it comes to simulations and that supplementing them with pre-access videos that represent the actual procedure can improve student learning.

When pre- and post-Q test correct answers were compared regardless of the student group, in question 4, there were no significant changes. We suspect that the students' understanding regarding the treatment sequence did not show differences because they already started with good results in the pre-Q (89.5% correct answers).

It has been demonstrated that the improvement in learning through an FC is increased with the incorporation of qualified tests.[9] In this sense, Hew et al. stated that the use of tests at the beginning of the class would make the FC more effective. One explanation for this finding is that these tests help students remember the knowledge learned before class. However, Chutinan et al. applied the FC in a module of dental anatomy and observed that the immediate evaluation improved, but not the evaluation at the end of the academic year.[16]

It is important to note that, in order for the FC to be effective, students must have access to the digital material before the class begins. In our case, X (59%) students viewed the video during the time they had it available (in the 7 days before the start of the class, taking into account that the knowledge explained was very specific and enough time was allotted for learning the concepts), which we consider to be a good result. Of those who did not, five did not attend the class, one claimed to have technical problems, and another five viewed the video the same day as the class (up to 30 min before). A remarkable fact is that two students who had not seen the video previously did so after class, when they had already practiced. Therefore, we consider that it is necessary to increase the students' motivation to view the videos. Further, if the students had had some type of graded exam before the actual class, the viewing of the video would have been greater.

When we asked the students how many times they had seen the video, the most popular response was two or three times (Table 2). However, when the teacher with the right to edit checked it through the "reports: all entries from participants" tool on the virtual campus, we saw that the average number of views was lower. Also, it would have been very interesting to see whether these visualisations were complete. Therefore, although one of the advantages of using this methodology is accessing information as many times as necessary for learning, it is clear that students are not aware of it and do not use it. Perhaps this is because they continue to consider the teacher's explanation as the basis for learning. In other studies, such as the one by Torre et al.,[5] something similar happened because although 88% of the participants rated this method as very good, 75% had not previously accessed the material. In our opinion, it is important that before introducing FC, students should be adequately instructed in their methodology.

In general, almost all the students found it very useful or useful to have videos on the virtual campus and to be able to preview the videos. Most of the students (85.5%) believe that watching the explanatory videos before class makes that class easier. However, a high percentage of students believe that incorporating the videos into other platforms specifically designed for this type of teaching would increase their interest and make it easier for them. Therefore, we believe that we can qualify our results as positive, coinciding with other authors who used the FC in different fields of dentistry, such as dental anatomy,[7] paediatric dentistry,[8,9] dental prosthesis[17] and local anaesthesia.[12,18]

5 | CONCLUSIONS

Considering the results obtained, implementing FC in the paediatric dentistry II course has improved learning. Furthermore, the degree of student satisfaction with this teaching technique has turned out to be very positive.

Our study results suggest that the implementation of FC in paediatric dentistry classes was associated with an increase in students' theoretical knowledge, which can be used for the practical application of dentistry techniques.

CONFLICT OF INTEREST

There is no conflict of interest affecting any of the authors of this work.

AUTHOR CONTRIBUTIONS

All the authors have made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data; and have been involved in drafting the manuscript or revising it critically for important intellectual content; and given final approval of the version to be published.

ETHICAL APPROVAL

This study was approved by the Vice-chancellor for Quality of the Complutense University of Madrid (UCM) (reference no. 177) for the 2018 to 2019 call for Educational Innovation Projects of the UCM.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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