

## Original Article

# Dental education: Lecture versus flipped and spaced learning

Shivani Kohli<sup>1</sup>, Ashwin Kumar Sukumar<sup>1</sup>, Cheah Tze Zhen<sup>2</sup>, Andrew Sim Lim Yew<sup>2</sup>, Alvena Ann Gomez<sup>2</sup>

<sup>1</sup>Department of Prosthodontics, Faculty of Dentistry, MAHSA University, <sup>2</sup>Postdoctoral Student, Faculty of Dentistry, MAHSA University, Selangor, Malaysia

## ABSTRACT

**Background:** Even though there are diverse varieties of teaching methods to motivate and educate students, not many are used in dental institutions, where most rely only on traditional lectures. Hence, the objective of this study was to compare traditional lectures with newer teaching methods, specifically the flipped classroom and spaced learning method.

**Materials and Methods:** In this prospective cohort study Students were randomized to one of the teaching methods, and their short-term (immediately after teaching) and long-term (i.e., 6 months later) knowledge retention was assessed through multiple choice questions, followed by students feedback which was obtained using Trierer Inventar zur Lehrevaluation questionnaire.  $P \leq 0.05$  was considered statistically significant.

**Results:** For short-term learning gains, spaced learning group (165.85) showed highest mean scores, followed by the traditional lecture group (163.70) and flipped classroom group (153.25).  $P$  value acquired through the Kruskal–Wallis ANOVA was statistically significant (0.003). For long-term knowledge retention, traditional lecture group has highest mean scores (147.50), followed by spaced learning group (146.90) and flipped classroom group (145.05) with no significant difference ( $P = 0.657$ ).

**Conclusion:** Spaced learning methodology was better than the traditional lecture method and the flipped classroom concerning knowledge gains when measured immediately after the application of learning method. For long-term knowledge retention, both the flipped classroom and spaced learning teaching methods were comparable to the traditional lecture method.

**Key Words:** Feedback, knowledge, lecture

Received: October 2017  
Accepted: December 2018

**Address for correspondence:**  
Dr. Shivani Kohli,  
Department of  
Prosthodontics, Faculty of  
Dentistry, MAHSA University,  
Selangor, Malaysia.  
E-mail: shivani@mahsa.  
edu.my

## INTRODUCTION

One of the serious challenges that dental educators face today is to improve the learning environment to suit students of different learning styles.<sup>[1]</sup> Incorporation of newer teaching methods has shown improvement in cognitive, educational goals among the students.<sup>[2-5]</sup> Current dental education is almost exclusively reliant on traditional lectures.<sup>[6]</sup> Although lectures have benefits of providing the lecturer's

personal overview of the material, integrating information from multiple sources, and clarifying complex information; however, it lacks application and critical thinking tasks.<sup>[7,8]</sup> It has been shown that critical thinking can be improved by providing interactive learning methods.<sup>[9]</sup> Hence, it is important to introduce newer teaching methods to the students aiming toward interactive learning.

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

**For reprints contact:** reprints@medknow.com

**How to cite this article:** Kohli S, Sukumar AK, Zhen CT, Yew AS, Gomez AA. Dental education: Lecture versus flipped and spaced learning. Dent Res J 2019;16:289-97.

Access this article online	
	<p><b>Website:</b> www.drj.ir www.drjjournal.net www.ncbi.nlm.nih.gov/pmc/journals/1480</p>

Flipped classroom is a growing drive in higher education that emphasizes educators to change around the learning atmosphere and to use valuable class time with learners. The term “flipped classroom” was coined by two high school chemistry teachers from Colorado, Jonathan Bergmann and Aaron Sams, who initiated flipping courses in 2007. They defined it as “that which is traditionally done in class is now done at home, and that which is traditionally done as homework is now completed in class.” They additionally described the flipped classroom as presenting students a modified personalized and customized education.<sup>[10]</sup> This is done by providing learning resources to address the varied learning necessities of students and transitioning classroom time to engross students in the application of content, formatively evaluate student advancement, and work individually or with groups of students as required. The flipped classroom model has ever since spread to numerous other teachers, professors, and professional development educators worldwide.<sup>[11]</sup> The flipped classroom has an exclusive approach, combining these same learning strategies with increasingly accessible technologies used to generate short video lectures (e.g., podcasts or vodcasts). Hereafter, more time is endorsed in the face-to-face classroom setting for application-level teaching approaches, engaging collaborative activities, and group discussions on content.<sup>[12,13]</sup>

Another interactive method of learning is the spaced learning methodology during which highly condensed learning material consisting of multiple inputs divided by short breaks during which distractor activities are performed.<sup>[14]</sup> Spaced learning is frequently studied within a single session by varying the number of intervening items. However, there has been relatively little investigation of spaced learning with learning sessions spread across a single day.<sup>[15]</sup> Certain concepts of memory consolidation recommend that effective memory consolidation might need periods of inactivity or rest.<sup>[16]</sup> Additional exposure to the studied words, repetitive testing would improve the knowledge of the novel words and provide added opportunity for the interleaving in memory of the novel words with existing words.<sup>[17]</sup>

Therefore, the students can develop cognitive skills such as memory, thoughtfulness, and critical discerning through exposure to different teaching methodologies, besides being able to elaborate and confirm their hypothesis.<sup>[18-20]</sup> In addition, students can

construct their knowledge in a more integrative way with greater enthusiasm to learn.<sup>[21,22]</sup>

Actually, memory is the process in which information is encoded, stored, and retrieved inside our brain. Memory can be simplified into short-term memory and long-term memory (LTM). Short-term memory is the capability for holding a small amount of information in mind in a readily available state for a brief period. There are two short-term storage mechanisms as follows: the phonological loop and the visuospatial sketchpad.<sup>[23]</sup> LTM is the final stage, in which data are stored for indefinite periods of time in contrast to short-term memory which usually persists for only about 20–30 s. LTM encodes information semantically for storage. The information needs to enter working memory before it can be stored in LTM. Furthermore, one of the core functions of education is creating LTM through a specifically curriculum with emphasis on the fundamentals of a desired field of study.<sup>[24]</sup>

Hence, this study was conducted to compare three different teaching methodologies for undergraduate dental students regarding knowledge retention. The three teaching methodologies selected for this comparison were conventional lecture, flipped classroom, and spaced learning. The objectives of this study were to compare between three different teaching methodologies for short-term and long-term knowledge retention and students perspectives toward it.

## MATERIALS AND METHODS

This prospective cohort study was conducted among 1<sup>st</sup>-year dental students, aged between 19 and 20 years in MAHSA University, a private institution that follows a traditional dental curriculum, principally incorporating lectures, tutorials, and a few problem-based learning sessions. Students’ education background principally generally relied on lectures only. This study was conducted between September 2014 and March 2015 among undergraduate dental students over 4 weeks with a total contact period of 280 min (70 min per session for 4 times). A total of 60 students participated in the study. Random sampling with random numbers was used to assign each student in one of three groups: Group A – 20 students for traditional lecture teaching method; Group B – 20 students for flipped classroom method; and Group C – 20 students for spaced learning

method. It was ensured that all the methods had the identical duration (1-h, once a week), and the teaching was delivered by the same lecturer. The lecturer had prepared each of the teaching methodologies strictly adhering to the methods stated in the literature,<sup>[7,12,14]</sup> and at the end of the session, a feedback was obtained from the students to evaluate the quality of the same.

The study design was approved by the Ethics Committee of MAHSA University. Out of 75 students, 60 students volunteered to participate in the study. Before their enrollment, all participants were informed regarding the objectives and methodology of the study, following which all gave informed consent. The topics taught were anatomy of teeth (types of dentition, dental anatomy and physiology, classification of teeth, functions of teeth and its surrounding structures, parts of a tooth, and dental tissues), dentin hypersensitivity (physiology, etiology, diagnosis, and treatment), dental caries (definition, mechanism for caries development, etiology of dental caries, and classification), and oral hygiene (What is oral hygiene, importance of oral hygiene, basic steps for maintaining oral hygiene, and consequences of not maintaining oral hygiene). The content of the topics was the same for all three groups, and the duration of each session was kept at 60 min.

For the conventional lecture (Group A), Microsoft PowerPoint (2010) slides, whiteboard, markers, and models were used to aid in the delivery of the content. For the Flipped classroom (Group B), the videos of the content were shot and distributed to the participants through E-mail 1 week before the scheduled session. Four short videos of 10–12-min duration were prepared for each topic. Preparation of short videos eased students in downloading, accessibility, and repetition if needed.<sup>[25]</sup> Videos were recorded using Canon D1100 camera and edited using Windows Movie Maker software by Microsoft (version 16.4.3522.110). During the lecture hour, discussion of the topic was held, and the student's questions were addressed. For the spaced learning (Group C) highly condensed, learning content was repeated three times, with two 10-min breaks during which distractor activities such as physical activities were performed by the students.<sup>[26]</sup>

To assess students' short-term learning gain and long-term knowledge retention, a set of multiple choice questionnaire ( $n = 40$  containing five

alternatives each) was developed and applied at two different points as follows: immediately after the class conclusion (posttest) and 6 months after the class conclusion (long-term surprise posttest). The questionnaire was specifically designed for this research. For tests, each question was given to a panel of five expert analysts to give their opinion whether the question was essential, useful, or irrelevant to measuring the construct under study. Content validity index of 0.99 was achieved which was considered as an evidence of good content validity. Measurement of the extent to which judges assign the same score to the same variable was interrater reliability which was 0.96, representing an excellent level of agreement (Kappa Analysis).

Following which all students gave their feedback through Trierer Inventar zur Lehrevaluation (TRIL) [Table 1] questionnaire which is a validated modular German questionnaire which was translated to English for better understanding. It was used to explore student perceptions toward classroom experience and different teaching methodology.<sup>[27,28]</sup> It comprised six topics, topic 1 ("structure and didactics") consists of six questions concerning lecturer's skills in didactics and structuring of the learning content. Topic 2 deals with the motivational skills of the lecturer consisting of eight questions. Topic 3 (five questions) addresses the lecturer's skills in creating a favorable climate during the course. Topic 4 comprised four questions pertaining to practical relevance of the course by providing a connection between theory and practice. Topic 5 subsumes three questions on different additional aspects of courses. The students of the flipped classroom and spaced learning group had to answer five additional questions concerning their attitude toward receiving content of the course in a different way [Table 2]. For all questions, the answers were given on a scale from 1 to 5 (1 = I totally disagree, 5 = I totally agree).

Performance between the groups was compared at two points of assessment. The marks obtained by participants were tabulated and subjected to statistical analysis.  $P \leq 0.05$  was considered statistically significant. The scores obtained by the participants were compared using the Kruskal–Wallis ANOVA and the results were tabulated. Grading of the scores was done for easy comparison of the results. The results of the TRIL questionnaire were also subjected to the Kruskal–Wallis ANOVA to determine the significance.

**Table 1: Gender-wise comparison for grades for all the groups**

Grades and percentages		Group A				Group B				Group C			
		Short-term		Long-term		Short-term		Long-term		Short-term		Long-term	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
90-100	A+									2	2		
80-89	A	2	13					14		3	8	2	2
75-79	A-	1	2	2	9	1	3	2	6	2	1	2	2
70-74	B+	1		2	4	1	4		8		1	3	3
65-69	B	1			2	1	1		3	1			
60-64	B-			1								1	
55-59	C+							1					
50-54	C												

## RESULTS

The gender-wise comparison of grades for all the groups shows females scoring more A grades (A+, A, and A-) than the males [Table 1]. The participants of traditional lecture group (Group A) scored the maximum number of A grades, followed by the spaced learning (Group C) and the flipped classroom group (Group B) when tested immediately after the application of teaching methodology [Table 2], with the statistical difference being significant ( $P = 0.025$ ). Furthermore, when tested 6 months later, the traditional lecture group participants (Group A) scored the maximum number of A grades, followed by Groups B and C with equal numbers; however, statistically, it was not significant ( $P = 0.1$ ).

The intergroup comparison of scores for both short-term learning gains and long-term knowledge retention displayed statistically significant difference ( $P = 0.003$ ) between the groups in short-term but for long-term knowledge retention, there was no significant difference ( $P = 0.657$ ) [Table 3]. It was also remarkable to note that all the groups showed a decrease in mean scores from short term to long term [Graph 1].

Table 4 shows the mean and standard deviation values of all the three groups for the TRIL questionnaire obtained from the participants. The Kruskal-Wallis ANOVA was performed on the results of all the questions, and a  $P$  value was derived. Among all the questions, only Question 13,15, 22, and 23 showed significant  $P$  values. Table 5 shows the segment of the TRIL questionnaire which evaluates the mean and standard deviation of the participants who had undergone alternative teaching methods, that is, the flipped classroom and spaced learning.

**Table 2: Comparison of grades within the three groups for short-term learning gains**

Grades	Short-term learning gains			Long-term knowledge retention		
	Group A	Group B	Group C	Group A	Group B	Group C
A+	0	0	4	0	0	4
A	14	7	11	11	8	4
A-	4	6	3	6	8	6
B+	1	5	1	2	3	5
B	1	2	1	1	0	1
C+	0	0	0	0	1	0
$\chi^2, P$		0.025			0.1	

**Table 3: Comparison for all the groups in short- and long- term knowledge retention**

Short/Long term	<i>n</i>	Mean	Std. deviation	Chi-square	<i>P</i>
Short term					
Conventional lecture	20	163.70	10.844	11.509	0.003*
Flipped classroom	20	153.25	11.050		
Spaced learning	20	165.38	13.677		
Total	60	160.85	12.938		
Long term					
Conventional lecture	20	147.50	9.231	0.840	0.657
Flipped classroom	20	145.05	10.625		
Spaced learning	20	146.90	10.319		
Total	60	146.49	9.966		

\*Kruskall-Wallis ANOVA-significant  $P \leq 0.05$

## DISCUSSION

Different students learn at different paces and most dental schools do not allow for a flexibility in the dental curriculum to suit all the students. This has become a big hurdle for the teachers to impart knowledge equally among all the students. Countless classrooms in higher education still expect students to attend lectures and receive course grades through examination. In the current age, traditional lectures are debated by some as obsolete and barely address the knowledge needs of today's

**Table 4: Trierer Inventar zur Lehrevaluation questionnaire: Students feedback toward different teaching methodology**

Questions	Conventional lecture		Flipped classroom		Spaced learning		P
	Mean	SD	Mean	SD	Mean	SD	
Topic 1: Structure and didactics							
Q1. The course materials (manuscripts, PowerPoint slides, etc..) provided during the course was helpful for the understanding of the learning content	4.25	0.64	4.1	0.64	4.1	0.45	0.60
Q2. Didactic aids (PowerPoint slides, models, etc.) were used in an adequate way	4	0.65	3.95	0.83	3.9	0.45	0.75
Q3. The lecturer gave short summaries in order to make clear which were the crucial points for the understanding of the topic	4.3	0.57	3.95	0.89	4.25	0.64	0.43
Q4. The time management of the lecturer was adequate	3.5	0.83	3.85	0.67	3.25	0.79	0.05
Q5. The learning contents of the single sessions were adapted to the learning targets	3.9	0.45	3.95	0.69	3.8	0.62	0.72
Q6. The course materials were always provided on time	3.2	1.11	3.15	0.93	3.7	0.66	0.09
Topic 2: motivational skills of the lecturer							
Q7. The style of speech of the lecturer was fluently and clear	3.9	0.72	3.75	0.97	3.85	0.59	0.83
Q8. The lecturer was able to explain difficult learning content in an understandable way	4.1	0.72	3.95	0.76	3.85	0.49	0.34
Q9. The lecturer's speech was acoustically understandable	3.95	0.76	3.75	0.91	3.85	0.49	0.70
Q10. The lecturer was able to keep contact to the audience (e.g., by eye-contact)	3.95	0.6	4	0.56	3.8	0.7	0.67
Q11. The lecturer created an inspiring atmosphere	3.45	0.83	3.35	0.93	3.4	0.6	0.88
Q12. The lecturer was able to deal with disturbances (technical problems, noisiness, etc.)	3.6	0.6	3.65	0.75	3.85	0.67	0.39
Q13. It was easy for me to remain concentrated during the course	3.05	1.05	3.2	0.89	3.6	0.6	0.01
Q14. I was inspired to follow the train of thoughts during the course	3.15	0.9	3.15	0.81	3.55	0.6	0.18
Topic 3: the lecturer's skills in creating a favorable climate							
Q15. The lecturer stopped discussions at the right point of time	3.45	0.6	3.65	0.75	3.6	0.68	0.05
Q16. The lecturer treated the students friendly and was open-minded	4	0.56	3.8	0.77	3.9	0.45	0.65
Q17. The lecturer allowed asking questions that concerned the learning content and answered them adequately	4	0.65	4.05	0.83	3.9	0.55	0.65
Q18. The students received the possibility to give feedback to the course	3.9	0.9	3.95	0.69	4.1	0.55	0.75
Q19. The lecturer was able to fulfill needs expressed by the students concerning content, structure, and organization of the topic	3.95	0.6	3.7	0.8	3.95	0.51	0.41
Topic 4: Practical relevance of the course							
Q20. During the course, the relation between theoretical knowledge and practical application was demonstrated	3.6	0.8	3.55	0.76	3.45	0.6	0.79
Q21. The learning content of the course was adequately illustrated by practical examples (case studies, clinical applications)	3.5	0.76	3.25	0.91	3.6	0.68	0.30
Q22. I was inspired to deal with the learning content critically	3.3	0.86	3.3	0.8	3.6	0.68	0.04
Q23. The practical relevance of the learning content should have been highlighted even more intensively	4.1	0.72	3.9	0.79	3.55	0.51	0.05
Topic 5: Questions on different additional aspects							
Q24. I prepared myself for the lectures on a regular basis (e.g., By reading additional literature)	2.7	0.92	2.8	0.95	2.65	0.75	0.90
Q25. I did follow-up course work on a regular basis (e.g., Discussion with other students or reading of additional literature)	2.8	0.89	2.95	0.1	3.15	0.93	0.51
Q26. The degree of difficulty of the course was (1=Too low, 2=Low, 3=Adequate, 4=High, 5=Too high)	3.1	0.31	3.4	0.5	3.25	0.55	0.09

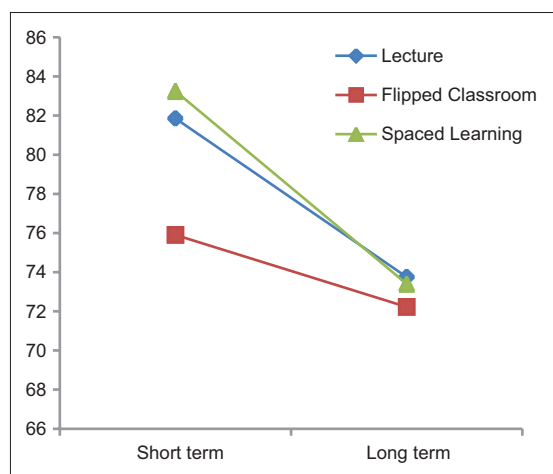
SD: Standard deviation

students.<sup>[29]</sup> The concept of the flipped classroom and spaced learning is a developing pedagogical approach. Although the terms may be relatively new, numerous of the underlying philosophies and techniques often used in a flipped class, including active learning, self-directed inquiry, student-centered instruction, and constructivist learning theory, have been meticulously researched and used successfully in a diversity of educational formats for years.<sup>[10]</sup>

Studies have shown that learning methods that provide educational alternatives for reasoning involving a problem-solving situation are more appropriate for learning.<sup>[30-34]</sup> A study conducted among the dental students in Chile concluded that the use of diverse and participative teaching methodologies in a remedial teaching intervention to cover all the different learning styles of the students contributes to improvement in their marks in formal evaluations.<sup>[1]</sup> This finding was in accordance with

**Table 5: The segment of the Trierer Inventar zur Lehrevaluation questionnaire to evaluate specifically the student's perception who underwent alternative teaching methods**

Topic 6: Flipped classroom evaluation		
Q1. Did you find the flip classroom learning method beneficial?	3.75	0.72
Q2. Did you find this method to have better understanding of the topic than conventional lectures?	3.65	0.81
Q3. Do you think this method can be incorporated as a teaching method in the curriculum?	3.75	0.72
Q4. Do you feel this method helps to study at your own pace and convenience?	3.85	0.88
Q5. Do you think that this method is time-saving than conventional lectures?	3.85	0.93
Topic 7: Spaced learning evaluation		
Q1. Did you find the spaced learning method beneficial?	3.45	0.94
Q2. Did you find this method to have better understanding of the topic than conventional lectures?	3.4	1.1
Q3. Do you think this method can be incorporated as a teaching method in the curriculum?	3.1	0.91
Q4. Does the repetition of the contents in the session help you to understand the topic better than conventional lectures?	3.9	0.91
Q5. Do the activities in between the session help you to focus more on the topic than conventional lectures?	3.25	0.91

**Graph 1:** Intergroup comparison between short and long term for knowledge retention.

our study where students agreed that these methods can be incorporated into our curriculum [Table 5] which suggests for curriculum reevaluation for health profession education. However, research to support the development of evidence-based guidelines for large-scale implementations is still lacking.<sup>[35,36]</sup>

Agreed to the enormous expansion in medical knowledge, it is both practical and expedient to make better usage of students' time with aids for effective learning, rather than increasing the length of time to earn a medical degree. As flipped classroom always comprises two mutually complementary parts, the first part of the learning action takes place independently from the classroom with video lectures or other stimuli for learning. The second part takes place in conjunction with the teacher and other students and requires group interactions.<sup>[37]</sup> Embracing a "flipped classroom" approach is a way to free up classroom time to uphold active learning through opportunities such as case-based and team-based exercises.<sup>[38,39]</sup>

Data seem to indicate a potential positive effect of the use of video lectures in this technologically enriched learning environment<sup>[40]</sup> which was comparable to the result found in the present study. In fact, the replay function of the lecture videos was perceived by some students as beneficial to independent learning, which was in accordance with another study conducted by Hanson among nursing students.<sup>[41]</sup> However, blending innovative teaching technologies with collaborative classroom activities can result in enhanced learning but not essentially improved student satisfaction.<sup>[42]</sup>

"Flips" among Masters of Public Health students gave a positive response for a design providing more opportunities for students to engage in critical thinking and facilitate their own learning independently, and more effectively interact with and learn from their peers. Moreover, the instructor was given more flexibility to cover a wider range and depth of material and offer timely feedback/guidance to students.<sup>[43,44]</sup>

For many types of learning, spaced training, which involves repetitive intertrial breaks, leads to more robust memory creation than does massed training, which encompasses short or no intervals. Computational models have estimated that spaced training with irregular intertrial intervals can also improve learning. This strategy of using spaced training protocols suggests innovative ways to rescue impaired synaptic plasticity and learning.<sup>[45]</sup>

As observed in the present study, spaced learning had a significantly greater impact than hours of continuous teaching, indicating that the spacing pattern is useful for LTM creation.<sup>[31,46]</sup> Kelley and Watson have demonstrated that LTM mechanisms of DNA synthesis at an intracellular level can be triggered using three stimuli spaced by two 10-min

periods without stimulation;<sup>[14]</sup> hence, similar patterns were used in the present study.

In the current study, the grades of students in the flipped classroom group were lower than the other two methods for both short-term and long-term knowledge retentions. This is in contrast with several other studies which have proven the effectiveness of the flipped classroom.<sup>[11,42-44]</sup> However, a comparison of our results shows the lowest percentage of decrease (4.8%) in flip classroom scores from short term to long term when compared to lectures (10%) and spaced learning (11%). The minimal decrease in performance from short-term to long-term assessment may be due to the accessibility and ability to repeat videos as and when needed.

To the best of our knowledge, the effect of spaced learning has not been described in dental education before. Earlier studies have hypothesized that students who accomplished well academically in a certain course were expected to positively assess their instructor.<sup>[47,48]</sup> Although the results from the present study direct that the students' academic performance did not affect their perception of how effectively the course was taught, reflecting the two variables were independent.

Educational performance has numerous diverse measures, besides learner's final grade.<sup>[48]</sup> It is wholly possible that the overall effectiveness of the flipped classroom lies in the fact that it promotes higher-order thinking, learning, and mastery of the subject on a consistent basis and throughout the course when compared to spaced learning where repetitive stimuli activate the temporal pattern for creating long-term memories.<sup>[13,14]</sup> In fact, TRIL questionnaire gave significant feedbacks from students both in flip classroom and spaced learning group as the students perceived that it was easier to concentrate in the class session (Question 13) and were more inspired to deal with the content critically (Question 22). Some of the comments of the students under flip classroom were "I like being able to replay lecture content through videos," "this method forces me to study beforehand" and from the students who had undergone spaced learning session were as follows "I think the break was just nice. Perfect to refresh a tired mind" and "it would be better if the activities in between were related to the subject." The participants of the traditional lecture group felt that "The practical relevance of the learning content should have been

highlighted even more intensively" than the other groups (Question 23, TRIL questionnaire). In a traditional lecture, the students commonly have the tendency to study more seriously just before the examinations. This fact could be a probable reason in the present study for the participants of spaced learning achieving highest mean test scores for short-term learning gains and students in the lecture group for long-term knowledge retention.

## CONCLUSION

The results of the present study showed that the spaced learning methodology was better than the traditional learning method and the flipped classroom concerning knowledge gains when measured immediately after the learning method application. For long-term knowledge retention, both the flipped classroom and spaced learning teaching methods were comparable to the traditional learning method based on the results and feedback from the participants. Henceforth, this should encourage the use of flipped classroom or spaced learning in a classroom environment in dental education as they help to reinforce critical thinking, inspire to learn new things, improve the ability to concentrate for the entire duration of the class, and even benefits the students to stop the discussions at the desired point of time. As dental education is facing alterations to improve young dentist's competency to respond better to the present-day needs of the patients, teaching methods need to be reviewed.

In future, this study can be extended to cover a larger student population across various faculties, and if the results are encouraging, the alternate teaching methods can become a part of the teaching curriculum. Furthermore, for better accessibility, an online forum needs to be created to permit the instructor to directly communicate with the students and address any pertinent questions in a timely manner before attending the actual class. Combination or blended learning is also a viable possibility where the alternate methods can be combined with the traditional methods.

### Financial support and sponsorship

Nil.

### Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

## REFERENCES

- Alcota M, Muñoz A, González FE. Diverse and participative learning methodologies: A remedial teaching intervention for low marks dental students in Chile. *J Dent Educ* 2011;75:1390-5.
- Fasce E, Ibañez P. Evaluation of a self-learning model applied to the teaching of electrocardiography to medical students. *Rev Chil Cardiol* 1991;10:45-50.
- Fasce E, Ibañez P. Long-term results of an independent study program of electrocardiography applied to medical students. *Rev Med Chil* 1994;122:133-40.
- Fasce E, Ramírez L, Ibañez P. Results of a problem-based learning experience applied to first year medical students. *Rev Med Chil* 1994;122:1257-62.
- Sayer M, Chaput De Saintonge M, Evans D, Wood D. Support for students with academic difficulties. *Med Educ* 2002;36:643-50.
- Miller CJ, McNear J, Metz MJ. A comparison of traditional and engaging lecture methods in a large, professional-level course. *Adv Physiol Educ* 2013;37:347-55.
- Matheson C. The educational value and effectiveness of lectures. *Clin Teach* 2008;5:218-21.
- Steinert Y, Snell LS. Interactive lecturing: Strategies for increasing participation in large group presentations. *Med Teach* 1999;21:37-42.
- Qiyun W, Huay LW, Jianhua Z. Investigating critical thinking and knowledge construction in an interactive learning environment. *Interact Learn Environ* 2009;17:95-104.
- Bergmann J, Sams A. *Flip your Class Room: Reach Every Student in Every Class Every Day*. Eugene, OR: International Society for Technology in Education; 2012.
- McDonald K, Smith CM. The flipped classroom for professional development: Part I. Benefits and strategies. *J Contin Educ Nurs* 2013;44:437-8.
- Hessler KL. Nursing education: Flipping the classroom. *Nurse Pract* 2016;41:17-27.
- Gavriel J. The flipped classroom. *Educ Prim Care* 2015;26:424-5.
- Kelley P, Watson T. Making long-term memories in minutes: A spaced learning pattern from memory research in education. *Front Hum Neurosci* 2013;7:589.
- Shea CH, Lai Q, Black C, Park JH. Spacing practice sessions across days benefits the learning of motor skills. *Hum Mov Sci* 2000;19:737-60.
- DeZazzo J, Tully T. Dissection of memory formation: From behavioral pharmacology to molecular genetics. *Trends Neurosci* 1995;18:212-8.
- Carrier M, Pashler H. The influence of retrieval on retention. *Mem Cognit* 1992;20:633-42.
- Driskell JE, Willis RP, Cooper C. Effect of over-learning on retention. *J Appl Psychol* 1992;77:615-22.
- Walliser B. A spectrum of equilibration processes in games. *J Evol Econ* 1998;8:67-87.
- Coyne R. Mindless repetition: Learning from computer games. *Design Stud* 2003;24:199-212.
- Ebner M, Holzinger A. Successful implementation of user-centered game based learning in higher education: An example from civil engineering. *Comput Educ* 2007;49:873-90.
- Hong JC, Cheng CL, Hwang MY, Lee CK, Chang HY. Assessing the educational values of digital games. *J Comput Assist Lear* 2009;25:423-37.
- Baddeley AD, Hitch G. *Working Memory: The Psychology of Learning and Motivation*. Vol. 8. New York: Academic Press; 1974. p. 48-79.
- Atkinson RC, Shiffrin RM. Human memory: A proposed system and its control processes. *The Psychology of Learning and Motivation*. Vol. 2. New York: Academic Press; 1968. p. 89-95.
- Moffett J, Mill AC. Evaluation of the flipped classroom approach in a veterinary professional skills course. *Adv Med Educ Pract* 2014;5:415-25.
- Douglas Fields R. Making Memories Stick. *Scientific American*; February, 2005. p. 58-63.
- Gläßer E, Gollwitzer M, Kranz D, Schlotz W, Schnell T, Voss A. Das Trierer Inventar zur Lehrevaluation (TRIL). Arbeitskreis "Lehrevaluation" im Fach Psychologie, Universität Trier. Available from: [https://www.psycharchives.org/bitstream/20.500.12034/368/1/PT\\_9004523\\_TRIL\\_weibl\\_DoZ\\_Fragebogen.pdf](https://www.psycharchives.org/bitstream/20.500.12034/368/1/PT_9004523_TRIL_weibl_DoZ_Fragebogen.pdf). [Last retrieved on 2019 May 27].
- Nkenke E, Vairaktaris E, Bauersachs A, Eitner S, Budach A, Knipfer C, *et al.* Spaced education activates students in a theoretical radiological science course: A pilot study. *BMC Med Educ* 2012;12:32.
- Mortensen CJ, Nicholson AM. The flipped classroom stimulates greater learning and is a modern 21<sup>st</sup> century approach to teaching today's undergraduates. *J Anim Sci* 2015;93:3722-31.
- Sweller J. Cognitive load during problem solving: Effects on learning. *Cogn Sci* 1988;12:257-85.
- Sweller J, van Merriënboer JJ, Paas FG. Cognitive architecture and instructional design. *Educ Psychol Rev* 1998;10:251-96.
- Rummel N, Spada H. Learning to collaborate: An instruction approach to promoting collaborative problem solving in computer-mediated settings. *J Learn Sci* 2005;14:201-41.
- Pearson J. Investigating ICT, using problem-based learning in face-to-face and online learning environments. *Comput Educ* 2006;47:56-73.
- Kester L, Lehnen C, Van Gerven PW, Kirschner PA. Just-in-time schematic supportive information presentation during cognitive skill acquisition. *Comput Hum Behav* 2006;22:93-116.
- Ojennus DD. Assessment of learning gains in a flipped biochemistry classroom. *Biochem Mol Biol Educ* 2016;44:20-7.
- Khanova J, Roth MT, Rodgers JE, McLaughlin JE. Student experiences across multiple flipped courses in a single curriculum. *Med Educ* 2015;49:1038-48.
- Merenmies J, Niemi-Murola L, Pyörälä E. Flipped classroom in basic medical education. *Duodecim* 2015;131:2009-15.
- Li S. Flip the classroom. *Educ Prim Care* 2015;26:438-40.
- Bethavas V, Bridgman H, Kornhaber R, Cross M. The evidence for 'flipping out': A systematic review of the flipped classroom in nursing education. *Nurse Educ Today* 2016;38:15-21.
- Corrias A, Cho Hong JG. Design and implementation of a flipped classroom learning environment in the biomedical engineering context. *Conf Proc IEEE Eng Med Biol Soc* 2015;2015:3985-8.
- Hanson J. Surveying the experiences and perceptions of undergraduate nursing students of a flipped classroom approach to increase understanding of drug science and its application to clinical practice. *Nurse Educ Pract* 2016;16:79-85.



42. Missildine K, Fountain R, Summers L, Gosselin K. Flipping the classroom to improve student performance and satisfaction. *J Nurs Educ* 2013;52:597-9.
43. Moraros J, Islam A, Yu S, Banow R, Schindelka B. Flipping for success: Evaluating the effectiveness of a novel teaching approach in a graduate level setting. *BMC Med Educ* 2015;15:27.
44. Park SE, Howell TH. Implementation of a flipped classroom educational model in a predoctoral dental course. *J Dent Educ* 2015;79:563-70.
45. Smolen P, Zhang Y, Byrne JH. The right time to learn: Mechanisms and optimization of spaced learning. *Nat Rev Neurosci* 2016;17:77-88.
46. Dong C, Sharma N. Spaced learning for continuous professional development in primary care. *Educ Prim Care* 2015;26:282.
47. Kulik JA. Student ratings: Validity, utility, and controversy. In: Theall M, Abrami P, Mets L, editors. *The Student Ratings Debate: Are They Valid? How Can We Best Use Them?* New Directions for Institutional Research. Vol. 109. San Francisco: Jossey-Bass; 2001. p. 9-25.
48. Kohn A. Beware of the standards, not just the tests. *Educ Week* 2001;38:52.