



Medical Education

Efficacy of co-teaching method in improving the engagement and academic performance of dental undergraduate students

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ABSTRACT

Objectives: The present study was conducted to test the efficacy of the co-teaching method in improving the performance of dental undergraduate students. The study holds an objective to devise a teaching method that improves the engagement and understanding of the students, overall enhancing the learning experience.

Materials and Methods: A 45-minute lecture on 'Biology of tooth movement' was delivered by a single instructor to the students with odd roll numbers and by 'Co-teaching method' to the students with even roll numbers. To objectively assess the retention and performance of the students, a post-lecture test comprising 15 multiple-choice questions related to the topic was distributed to all the students. To subjectively gauge the satisfaction levels of the students, they were also instructed to fill out a feedback form.

Results: The final study population for which the data were analysed comprised 82 students (13 males and 69 females). A significantly ($P < 0.05$) greater number of students in the control group belonged to the 'Second Class' and 'Fail' categories. On the contrary, the number of students in the 'Distinction' and 'First Class' categories of marks was significantly higher ($P < 0.05$) for the test group as compared to the control group. The odds ratio of qualifying was 2.255 times, and the scoring distinction was 19.92 for the students taught by the co-teaching method as compared to those taught by a single instructor.

Conclusion: The present study found the co-teaching method to be highly efficacious in improving the understanding, retention, recall and performance of the students.

Keywords: Dental education, Feedback, Learning, Students, Teaching.

INTRODUCTION

Knowledge of basic sciences such as anatomy, biochemistry, physiology and histology forms the foundation for understanding the clinical subjects in dentistry.^[1] These subjects, therefore, comprise the curriculum of the 1st year of the undergraduate course in India, while clinical subjects such as orthodontics, periodontics, oral surgery and endodontics are included in the later years of the course.^[2] The current educational pattern restricts to provision of knowledge related to the basic sciences to the new entry students so that they can understand the rationale behind various dental treatment procedures in the later years. For instance, it is crucial to be

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well-versed in the biological aspects of tooth movement to understand the concepts of orthodontics.

However, informing the students about the practical implications of a basic concept in dental practice would improve the interest of students to learn the topic. A recent survey of 2nd-year dental undergraduates in New Zealand found that the engagement and learning experience of the students was improved when they explained the practical relevance of the biochemical concepts in dentistry.^[3] Providing them with a purpose for learning the topic and inculcating a sense that it would, thus, be beneficial during dental practice serves to garner the interest of students.

The concept of biological tooth movement in itself is a complicated one involving an interplay of numerous biochemical and physiological processes.^[4,5] Such complex topics with a higher difficulty index also pose a hurdle for an instructor specialising in one subject who may not be able to convey information related to aspects other than his own as effectively as instructors specialising in the other fields.^[6] In simple words, an instructor in biochemistry would be able to better educate the students about the chemicals/nutrients/metabolites involved in tooth movement, a pathologist would be able to provide in-depth knowledge about the histological processes, and an orthodontist would be better able to explain the practical implications in clinical practice.

In this context, a lecture delivered by multiple instructors specialising in different fields can enable the students to better understand the respective aspects related to a topic. The strategy of collaborative teaching by multiple instructors, or in short, 'co-teaching', has been employed across some studies in an attempt to improve the interest and understanding of the students.^[3,7] Co-teaching is defined as 'well-planned, team-taught lessons, exhibit an invisible flow of instruction with no prescribed division of authority wherein all teachers are actively involved. From a student's perspective, there is no clearly defined leader, as both teachers share the instruction, are free to interject information and are available to assist students and answer questions.^[7] The method has been demonstrated to overcome several drawbacks associated with conventional lectures conducted by a single instructor. It enables the provision of in-depth knowledge about a topic from different perspectives by individuals specialising in the respective fields. The variation in personalities, voices and teaching styles also serves to eliminate the monotony associated with a single lecturer and extend the span of attention of the students.^[8,9]

The present study was conducted to test the efficacy of the co-teaching method in improving the performance of dental undergraduate students. The study holds an objective to devise a teaching method that improves the engagement and understanding of the students, overall enhancing the learning experience.

MATERIALS AND METHODS

The present randomised study was conducted in accordance with Helsinki's principles of research, and the protocol was approved by the Institutional Ethical Review Board (Ref No.: BEC 431082023).

Recruitment and allocation

A single batch of 100 students studying in the 1st year of undergraduate dental course at the institute were recruited for the present study. Informed consent was obtained and the students not consenting or those absent on the day of the study were excluded from the study. The students were alternatively allotted to either the test group (co-teaching method) or the control group (conventional lecture) based on their roll numbers. A 45-minute lecture on 'Biology of tooth movement' was delivered by a single instructor to the students with odd roll numbers and by a co-teaching method' to the students with even roll numbers.

Lesson plan

A single lesson plan was prepared by the researchers on the topic, which comprised various aspects related to tooth movement, including (i) phases and theories of tooth movement, (ii) histological changes, (iii) physiological and biochemical aspects and (iv) practical implications in orthodontics (optimum orthodontic force, hyalinisation). For the control group, a single instructor covered all the topics, while for the test group, different aspects related to the topic were subsequently covered by the respective subject specialists [Table 1]. Each instructor was trained in conducting lectures, which were prepared using Gagnes' instructional design, and they included:

(i) Gaining attention, (ii) informing students about the objectives, (iii) stimulus recall of prior learning, (iv) presenting a stimulus and providing learning guidance, (v) eliciting performance, (vi) providing feedback, (vii) assessing performance and (viii) enhancing retention and transfer.^[10]

Each instructor had prepared a short PowerPoint presentation of their topic. The presentations comprised a brief outline of the topic followed by key pointers and details on the subject. Short videos and animations were also incorporated into the slides to prevent monotonicity with the topic. Short questions were asked by the instructors to the students to enable them to express their views and provide them an opportunity to ask their doubts. Face-to-face interactions helped to provide insights into ambiguous questions prevailing in student's minds.

Outcome assessment

This study was to assess the retention and performance of the students objectively, a post-lecture test on the same day. The

Table 1: Lesson outline.

Aspect	Content covered	Subject specialist
Introduction	<ul style="list-style-type: none"> • Description on understanding of tooth movement in orthodontics. • Introduction to the three main components of the lesson: theories, biochemistry and clinical aspects. 	Orthodontist
Physiology and histology	<ul style="list-style-type: none"> • Theories of tooth movement: • Theories of tooth eruption • Theories of tooth movement • Phases of tooth movement • Histology during tooth movement 	Dental anatomy and oral histology (Oral Pathologist)
Biochemical and molecular	<ul style="list-style-type: none"> • Overview of the biochemical processes involved in tooth movement • Role of Vitamin D in eruption tooth movement • Role of osteoclasts and osteoblasts in bone remodelling. • Signalling pathways (RANK/RANKL/OPG pathway) Regulating bone resorption and formation. • Importance of extracellular matrix components such as collagen and proteoglycans in tooth movement. • Case study: Analysis of biochemical factors influencing tooth movement in patients with orthodontic treatment. 	Biochemistry
Practical implications	<ul style="list-style-type: none"> • Clinical aspects of tooth movement: • Different methods to induce tooth movement • Factors affecting tooth movement: Age, Hormonal conditions, Smoking, periodontal diseases, etc. • Case review: To formulate treatment planning for difficult cases. For example: long-standing edentulous spaces, presence of knife edge ridge, etc. 	Orthodontist
Conclusion	<ul style="list-style-type: none"> • A brief overview of topics covered in the lesson. • Importance of interdisciplinary collaboration between faculties of Orthodontics and Biochemistry to help understand the intricate details of the topic 	Dental anatomy and oral histology (Oral pathologist)

RANK: Receptor activator of nuclear factor kappa-B, RANKL: Receptor activator of nuclear factor kappa-B Ligand, OPG: Osteoprogenin

test comprised 15 multiple-choice questions (MCQs) related to the topic that had a single best response. A score of 50% of the total marks (7.5 out of 15) was considered for passing. To subjectively gauge the satisfaction levels of the students, they were also instructed to fill out a feedback form. The feedback form comprised seven questions related to Gagne's principles for which the students were required to grade on a scale of 1–3 as 'not effective', 'effective' or 'very effective', respectively. The contents of the test, as well as feedback questionnaires, were validated by five subject experts. The teachers were blinded to the questions of the post-session test.

After completion of the study, co-teaching was conducted for students taught with a single instructor teaching method to practice 'Educational justice' and prevent any kind of academic loss to the study mentioned above group.

Statistical analysis

The data were obtained and entered in a Microsoft Excel Sheet and subjected to statistical analysis using IBM Statistical Package for the Social Sciences version 21. Depending on the marks obtained, the students were categorised as fail (<50% marks), second class (50–64% marks), first class (65–74% marks) and distinction (>75% marks). The number of students in each category was recorded for both groups.

Descriptive statistics of the marks obtained and feedback provided by the students of both groups were performed. For evaluating the difference in proportion, the Chi-square test of proportion was applied. Inter-group comparison of the number of students in each category and feedback responses was performed by the Mann–Whitney U-test.

RESULTS

The final study population for which the data were analysed comprised 82 students (13 male and 69 female). The categorical distribution of students according to the marks scored in the post-lecture test is depicted in Figure 1. More than 75% of students ($n = 62$) passed the test, while $n = 20$ students failed. Among the failing students, the number of students in the control group was significantly higher ($P < 0.05$) as compared to those from the test group. In addition, there was a statistically significant difference ($P < 0.05$) in the gender of the students failing, with the number of males being proportionately higher.

After scoring the post-session MCQ tests, it was observed that there were more students in the control group that scored in the 'Second Class' and 'Fail' categories as compared to the co-teaching group, and this difference in the number of students was statistically significant ($P < 0.05$). On the contrary,

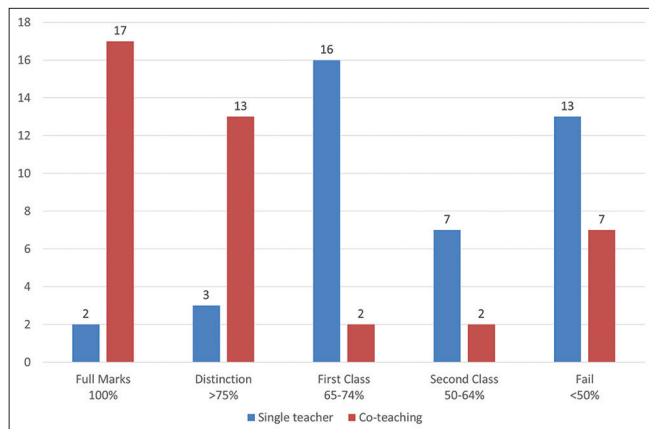


Figure 1: Number of students scoring different categories of marks in each group.

the number of students in the 'distinction' and 'first class' categories of marks was significantly higher ($P < 0.05$) for the test group as compared to the control group. A total of $n = 19$ students obtained full marks, of which the majority ($n = 17$) belonged to the test group. The odds ratio of qualifying was 2.255 times and the scoring distinction was 19.92 for the students taught by the co-teaching method as compared to those taught by a single instructor [Table 2]. No significant gender-based differences were noted in categories other than 'Fail' wherein the number of females was significantly higher.

A significantly higher number of students ($P < 0.05$) in the test group responded as 'very effective' for the majority of the questions as compared to those in the control group [Table 3]. There were no significant differences observed between the feedback responses provided by students of either gender.

DISCUSSION

The present study aimed to gauge the efficacy of the co-teaching method in improving the performance of dental undergraduate students with the objective of devising a teaching method that is able to improve the engagement and understanding of the students. The single instructor delivering the lecture was an expert in the subject on which the lecture was delivered. The syllabus and sub-topics are standardised by the University. The single instructor covered the same topics that were covered by the three instructors in the same amount of given time. Giving them the same MCQs provides an opportunity to compare the true difference between the two methods.

It was observed that 90% of the students who scored full marks were taught by the co-teaching method. A significantly greater number of students in the control group belonged to the lower categorical strata of marks as compared to those taught with the co-teaching method. In addition, the self-perception form filled by the students revealed a higher affinity for the co-teaching method in comparison with single instructor teaching method.

Table 2: OR for qualification and distinction with co-teaching against single teaching method.

	OR	95% C.I.		P-value
		Lower	Upper	
Qualification	2.255	0.792	6.420	0.128
Distinction	19.923	5.862	67.718	<0.0001

OR: Odds ratio, C.I.: Confidence interval

Under normal conditions, the threshold attention span for most adults is considered to be 20 min on average.^[11] While single-instructor lectures have been the gold standard of teaching in the medical education system, the students tend to lose interest in learning after this threshold period due to the monotony. Most of the dental colleges in India have a strength of 100 undergraduate students per year. It is a daunting task for a lecturer to maintain the active attention of such a large audience throughout the duration of the session.^[12] Consequently, the retention and recall of the information provided during the lecture becomes reduced.

Even so, the single instructor method being the standard of teaching in India reiterates the fact that the students were not deprived of any education. This was, in fact, the basis of the study that sought to see the efficacy of the co-teaching method. However, keeping in mind the 'Educational Justice' as a part of ethical consideration, an additional session of co-teaching was included for the students in the single-instructor group in the study protocol.

Since the co-teaching method used in the present study involved multiple lecturers delivering knowledge in small sections related to the subjects of their specialties, a certain element of versatility was introduced. The different lecturing styles of the respective instructors refreshed the student's cooldown of attention span by breaking the pattern of monotony associated with the conventional methods of teaching. In addition, exposing the children to the clinical prospects of the basic sciences piqued their interest in the subjects. This was supported by the fact that about 55% of the students deemed the co-teaching method as highly effective in gaining their attention as compared to 17% in the conventional group.

At the same time, since instructors specialising in different subjects are providing in-depth knowledge related to their fields, the quality of knowledge delivered was substantially improved. The students are able to visualise the topic from different perspectives that vastly enhance the learning experience. These statements are reinforced by the observation that a significantly greater number of students found the co-teaching method highly effective in making them understand the objective and retain and recall the contents taught in the lecture as compared to the control group. The previous studies have also reported improvement in student involvement and retention

Table 3: Comparison of the feedback responses between single teacher and multiple teachers.

	Not effective	Neutral	Highly effective	Total	P-value
How effective was the teaching method in gaining your attention during the lecture?					
Single teacher					0.001
N	9	23	7	39	
%	23.1	59.0	17.9	100.0	
Multiple teacher					
N	0	19	23	42	
%	0.0	45.2	54.8	100.0	
Total					
N	9	42	30	81	
%	11.1	51.9	37.0	100.0	
How effective was the teaching method in helping you understand the concept/objectives behind the topic?					
Single teacher					0.001
N	4	28	7	39	
%	10.3	71.8	17.9	100.0	
Multiple teacher					
N	1	17	24	42	
%	2.4	40.5	57.1	100.0	
Total					
N	5	45	31	81	
%	6.2	55.6	38.3	100.0	
How effective was the teaching method in stimulating you to recall information taught by the instructor during the lecture?					
Single teacher					0.001
N	11	24	4	39	
%	28.2	61.5	10.3	100.0	
Multiple teacher					
N	0	22	20	42	
%	0.0	52.4	47.6	100.0	
Total					
N	11	46	24	81	
%	13.6	56.8	29.6	100.0	
How effective was the teaching method in guiding you to learn and remember what was being taught?					
Single teacher					0.001
N	7	25	7	39	
%	17.9	64.1	17.9	100.0	
Multiple teacher					
N	0	17	25	42	
%	0.0	40.5	59.5	100.0	
Total					
N	7	42	32	81	
%	8.6	51.9	39.5	100.0	

(Contd...)

Table 3: (Continued).

	Not effective	Neutral	Highly effective	Total	P-value
How effective was the teaching method in helping you to practically apply what was taught during the lecture?					
Single teacher					0.001
N	10	22	7	39	
%	25.6	56.4	17.9	100.0	
Multiple teacher					
N	1	16	25	42	
%	2.4	38.1	59.5	100.0	
Total					
N	11	38	32	81	
%	13.6	46.9	39.5	100.0	
Provide a feedback for the teaching method					
Single teacher					0.001
N	7	26	6	39	
%	17.9	66.7	15.4	100.0	
Multiple Teacher					
N	0	18	24	42	
%	0.0	42.9	57.1	100.0	
Total					
N	7	44	30	81	
%	8.6	54.3	37.0	100.0	
How effective was the teaching method in helping you to retain the information taught in the lecture after the test?					
Single teacher					0.001
N	7	27	5	39	
%	17.9	69.2	12.8	100.0	
Multiple teacher					
N	0	20	22	42	
%	0.0	47.6	52.4	100.0	
Total					
N	7	47	27	81	
%	8.6	58.0	33.3	100.0	

achieved by an interdisciplinary teaching approach.^[13-15] However, it is important to take cognizance of the fact that some studies concerning co-teaching had inadequate sample sizes, demonstrated contradicting results or failed to achieve statistical significance in improving student scores as compared to the single instructor model.^[16,17] These inconsistencies may be attributable to various confounding factors such as study design, demographics and variations in teaching conditions.

The method can also serve to improve professional relations between the faculty of different specialties of a dental or medical college.^[18,19] It could also instil a sense of healthy competition among the instructors, with each aiming to

make the students understand the concepts better. The only drawback of the co-teaching method noted in the present study was that it required thorough preliminary lesson planning and distribution of the contents. This alludes to the fact that longitudinal studies are to be conducted to assess the effects of co-teaching on students' performance, student learning objectives and faculty collaborations.^[20] The future scope of the study lies in the challenge of evaluating the effectiveness of collaborative teaching methods in diverse dental education perspectives with different dental institutions with varying syllabi in their prescribed curriculum.

Overall, co-teaching in medical education has added benefits, including the ability to draw on diverse expertise, promote active learning and foster interdisciplinary collaboration among faculty. The current curriculum design should encourage interdisciplinary teaching in view of orchestrating an extraordinary form of learning allowing active involvement of students and different teaching faculty.

CONCLUSION

The present study found the co-teaching method to be highly effective in improving the understanding, retention, recall and performance of the students. The method enabled improved engagement of the students by creating an interest in learning and enhanced the learning experience and collaboration among the teaching faculty.

Ethical approval: The research/study approved by the Institutional Review Board at Bharati Vidyapeeth (Deemed to be University) Dental College and Hospital, Navi Mumbai, approval number BEC 431082023, dated 9th August 2023.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent.

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