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Effect of flipped classroom on student perceptions, academic scores and study practices

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ABSTRACT

Aim. To evaluate the educational impact of two flipped classroom models.
Material and methods. Traditional lectures were followed by Flipped classroom (FC) with face to face(F2F) session (cohort of 2019-20) and online (cohort 2020-21). Students' perceptions were collected by questionnaire after lectures and FC. Historic academic scores on selected topic were compared scores after introduction of FC. The learning management system(LMS) was used to monitor student usage of learning resources.
Results. Students perceptions for cohort 2019-20 were significantly higher($p>0.05$) for FC(F2F) compared to lecture. Students' perceptions for cohort 2020-21 were also significantly higher for FC(online) compared to online lecture. Academic scores did not show significant difference between lecture and FC. Increased hits on LMS for online resources were associated with FC or summative assessment.
Conclusions. Students were overwhelmingly positive on FC for both: with F2F and online , and academic scores were similar to lecture. FC can possibly improve student study habits but needs further research.

Introduction

A lecture, as a teaching method, inherently suffers from being able to focus largely on the lower levels of cognition, leaving little or no time to address the higher levels [1]. A passive transfer of knowledge and an instructor centric relationship is deemed to be unsuitable for the current generation of learners [2]. The flipped classroom (FC) has garnered considerable attention as an alternative to the traditional lecture. The FC is a variant of blended learning [3,4]. Broadly, FC model involves provision of learning resources online prior to the face to face (F2F) session. The resources are utilized by students to acquire lower- level cognitive knowledge, creating sufficient time in the formal

F2F session to address higher levels, by engaging in active learning strategies [5].

The FC model has been extensively researched, particularly in higher education. Literature in health sciences has also been growing and systematic reviews or meta-analyses on certain aspects of the flipped classroom [6,7] have been conducted. In dental education, studies have reported a positive effect of FC on student perception [8]. Nevertheless, the influence of FC on academic scores has yielded mixed results [9] and literature describing its effect on behavioral change is limited.

The advent of COVID-19 pandemic has resulted in most dental schools conducting the didactic sessions online [10] and "ensuring the continuity and quality of dental education" is a challenge [11] that needs rapid adaptation of existing teaching strategies to engage students effectively. Under the circumstances, all didactic activities were shifted to online mode and the F2F session in the FC was replaced with an online one.

Thus, the aim of the study was; to evaluate the educational impact of two FC models.

Research questions

1. What is the effect of the FC models (F2F and online) on student perceptions.
2. What is the effect of flipped classroom on the academic scores (in didactic component).
3. What is the effect of FC on study habits of students?

Materials and methods

The FC was introduced to final year students of dentistry program in the course: Comprehensive orthodontics and pediatric dentistry. **Figure 1** is describing flow chart showing the key considerations and activities during implementation of the FC (conventional/online).

The cohort for 2019–20 had 95 students. The FC was implemented after approval from the institutional ethics committee and research center board coupled with support from the IT department. A workshop was conducted by the institutional medical education unit to orient faculty and help design the FC model. Extensive review of literature was performed to establish a resource for reference during the implementation.[12] An orientation class was conducted for the students prior to the FC wherein they were introduced to the concept of FC and the necessity of varied methods of teaching was explained. The first 3 topics of the course were conducted by traditional lecture (50 minutes each) and at the end of these lectures, students were asked to respond to a pretested questionnaire on the traditional lecture. Topics "pulp therapy in primary and young permanent dentition" (10% of the didactic component of the course) were selected to be conducted as a FC. Traditionally, these were conducted as 2 separate lectures of 50 minutes each.

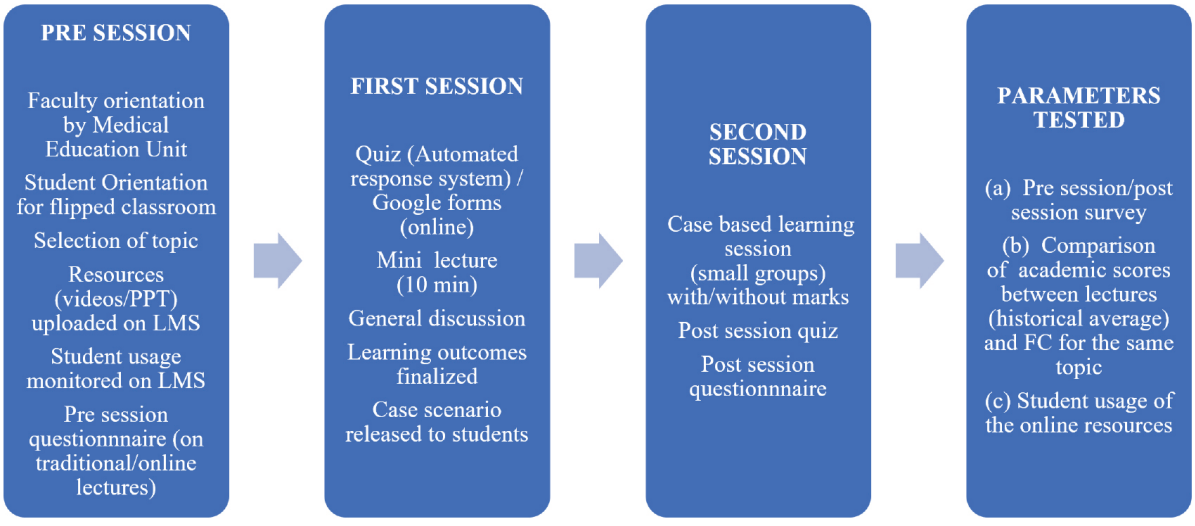

Figure 1. Flow chart showing the key considerations and activities during implementation of the FC (conventional/online).

FC (F2F)

Resources including: video recorded lectures(VRL), power-point(PPT) presentations of lectures, and links to external open access sources such American Academy of Pediatric Dentistry (AAPD) guidelines, were uploaded on the Learning Management System(LMS), Moodle, 1 week before the session.

The flipped classroom (F2F) consisted of two sessions. In the first session(40 minutes), students were initially exposed to a quiz including questions on both the topics that were uploaded one week before the lecture. The quiz was conducted with POWER VOTE™ (Automated response system) and the correct answers were displayed in real time. Results were used to give feedback and clarify student's misconceptions. This was followed by a mini lecture of 10 minutes and a general discussion on questions with students. A case scenario designed by faculty were released to the students and learning outcomes were established for the next session scheduled one week later.

In the second session, students were divided into smaller groups (7 or less) for a case-based learning session(CBL) for a duration of 80 minutes. The scenario consisted of a brief introduction to the problem, followed by sequential disclosure of history, findings of clinical examination and investigations. CBL sessions included role play by faculty (for parts of history taking) and summary (5 minutes at end of the session). Students were assessed with case- based assessment sheet using analytic rubrics. All other activities in the course were kept the same as previous years. The summative assessment was a mix of MCQ's and short answer questions(SAQ). The selected topic had a total of 10 MCQ's and 1 SAQ included in the assessments. The questions were framed by a single faculty for all the years and the assessment was verified by a committee.

FC (online)

In the year 2020–21, all the lectures were conducted online due to the COVID-19 pandemic. The F2F session was substituted with an online one conducted on ZOOM. Online quiz was conducted with Google forms and case- based learning session was conducted using breakout rooms. Additionally, students were asked to prepare and submit a concept map (1 per group) for the case scenario. The session was also assigned marks (2.5% out of overall 100) and students were informed the same during orientation sessions.

Students of both years responded to a pretested post session questionnaire on their perceptions of the FC. The first seven questions of both pre-session questionnaire and post session questionnaires were a comparison between lectures and flipped classroom. The post session questionnaire session also consisted of 4 additional questions exclusively on the flipped classroom. All the responses were kept anonymous.

Statistical analysis

The statistical analysis was conducted using SPSS version 30. Descriptive statistics were analysed using the median and range for the likert scale responses. Mean and standard error was used to compare between the cohorts for the multiple choice questions and the short answer question. A Mann-Whitney U test was employed to compare between the two cohorts and within a cohort to compare between lecture and flipped classroom. The p value of < 0.05 was considered to be statistically significant.

Results

(A) Survey

A total of 93 responses (2019–20) and 76 responses (2020–21) were considered for the study. The responses of the survey and academic scores were expressed as median and range. The first 7 questions were comparisons between lecture and FC. For the cohort of 2019–20, and the difference between means was statistically significant for 5 questions ($p < 0.05$) (**Table 1**) Within questions on FC alone, "I recommend flipped classroom for the same course or other courses" showed the highest score for the cohort of 2019–20 (**Table 2**). For the cohort of 2020–21, the difference between the cohorts was statistically significant for 3 questions (**Table 3**).

(B) Academic scores

Comparison was made between academic scores of 3 consecutive years on the same topic taken as

Table 1. Comparison of medians between survey responses on lecture and flipped classroom by Mann-Whitney U test. Responses were recorded on a 5 point Likert scale (1 = strongly disagree to 5 = strongly agree).

Cohort of 2019–20 (n = 93)	Lecture		Flipped classroom		Mann-Whitney U test
Comparison between survey responses on lecture and flipped classroom	Median	Range	Median	Range	p
Lectures help me understand the subject better / Flipped classroom helps me to understand the subject better*	2	4	1	4	<0.001
Lectures help me to remember important concepts/ Flipped classroom helped me to remember important concepts*	2	3	1	4	<0.001
Lectures are interesting and engaging / Flipped Classroom Is Interesting And Engaging*	3	4	1	4	<0.001
During lectures I can discuss my difficulties with my teacher and classmates / During flipped classroom I can discuss my difficulties with my teacher and classmates*	3	3	2	4	<0.001
I feel confident that I will perform better in clinics because of the lecture / I feel confident that I will perform better in clinics because of the flipped classroom	2	3	1	2	<0.001
I feel confident that I will perform better in the theory exam because of the lecture / I feel confident that I will score good marks in the theory exams because of the flipped classroom*	2	3	2	3	0.398
If lectures are uploaded on moodle before coming to the class, I will read and come to the session / I watched all the videos of lectures on moodle before coming to the class*	2	3	3	4	<0.001

* p value < 0.05 was considered to be statistically significant.

Table 2. Median and range of survey responses on flipped classroom(conventional and online) exclusively between the two cohorts. Responses were recorded on a 5 point Likert scale (1 = strongly disagree to 5 = strongly agree).

Survey response on flipped classroom (exclusively)	Cohort 2019–20		Cohort 2020–21		Mann-Whitney U test
	Median	Range	Median	Range	p
I prefer traditional lecture as compared to flipped classroom	2	4	4	4	<0.001
I feel videos of lectures are very useful since they help me to watch them anytime	4	4	4	3	0.612
I recommend flipped classroom for the same course or other courses as well	1	4	4	4	<0.001
I had to put more effort for the flipped classroom as compared to lecture	3	4	4	4	<0.001

Table 3. Comparison of medians between survey responses on online lecture and online flipped classroom by Mann-Whitney U test. Responses were recorded on a 5 point Likert scale (1 = strongly disagree to 5 = strongly agree).

Cohort of 2020–21 (n = 76)	Online lectures		Flipped classroom (online)		Mann-Whitney U test
Comparison between survey responses on lecture and flipped classroom	Median	Range	Median	Range	p
Online Lectures help me understand the subject better / Flipped classroom helps me to understand the subject better*	4	4	5	4	0.001
Lectures help me to remember important concepts / Flipped classroom helped me to remember important concepts*	4	4	5	3	<0.001
Lectures are interesting and engaging / Flipped Classroom Is Interesting And Engaging*	4	4	4	3	<0.001
During lectures I can discuss my difficulties with my teacher and classmates / During flipped classroom I can discuss my difficulties with my teacher and classmates	4	4	4	4	0.591
I feel confident that I will perform better in clinics because of the lecture / I feel confident that I will perform better in clinics because of the flipped classroom	4	4	4	4	<0.001
I feel confident that I will perform better in the theory exam because of the lecture / I feel confident that I will score good marks in the theory exams because of the flipped classroom	4	3	4	4	0.044
If lectures are uploaded on moodle before coming to the class, I will read and come to the session / I watched all the videos of lectures on moodle before coming to the class.	5	2	4	3	0.012

Table 4. (A) Comparison between mean scores and standard error between scores (10 MCQ's and 1 SAQ) for years 2016–17, 2017–18,2018–19 from traditional lectures and (10 MCQ's and 1 SAQ) for 2019–20, 2020–21 of traditional FC and online FC respectively.

Cohort	Mean	Standard error	p
2016–17	65.93	3.56863	0.941
2017–18	73.42	2.68143	
2018–19	70.30	2.87547	
2019–20#	70.11	3.08010	
2020–21	74.12	2.44013	

* p value < 0.05 was considered to be statistically significant.
# MCQ's in the years 2019–20 that were part of the exam conducted online with students at home were not included.

Table 5. Statistics of students access to video's and PPT uploaded prior to FC and lectures.

	Resource	1st phase	2nd phase	3rd phase	Overall hits	Hits Per student	Percentage of students utilizing the resources
FC (F2F)	VRL	164	10	4	178	3.24	71.6%
	PPT	27	26	71	124		
	Total	191	36	75	302		
	p value	0.001					
TL	VRL	0	0	39	39	1.98	58.3%
	PPT	48	20	77	145		
	Total	48	20	116	184		
	p value	0.001					
FC (O)	VRL	99	2	4	105	3.57	74%
	PPT	106	11	53	170		
	Total	205	13	57	275		
	p value	0.001					
OL	VRL	0	0	53	53	2.42	59.7%
	PPT	43	29	62	134		
	Total	43	29	115	187		
	p value	0.001					

VRL – video recorded lectures; PPT – power point presentations; FC(F2F) – flipped classroom with face to face session; TL – traditional onsite lecture; FC(O) – flipped classroom with F2F session conducted online; OL – online lecture.
1st Phase = 20 days from the activity (lecture of FC). 3rd Phase = 20 days prior to the summative period. 2nd phase: Days in between 1st and 3rd phase.

a traditional lecture and scores of 2 years wherein the topic was conducted as FC. The academic scores between all the years showed no statistically significant difference (**Table 4**).

(C) Utilization of resources

The time period during which both FCb (F2F) and FC (O) was implemented, showed significantly increased number of hitsb ($p < 0.001$) compared to the period where summative assessment was conducted or neither of these activities were being conducted (**Table 5**). The hits were highest for the VRL during FC, while the PPT presentations were used the most, closer to the summative assessment. ($p < 0.001$) (**Figure 2**).

Discussion

Student perceptions

In the current study, the students' response was overwhelmingly positive on the flipped classroom. Students of both cohorts found the FC interesting and engaging compared to the lecture irrespective of whether it was conducted onsite (F2F) or online. The constructs exclusively on students' perceptions on FC also reported a significant positive opinion on the utility of videos of lectures and a desire to see increased number of sessions of FC in the future.

The questionnaire also included questions designed to evaluate students' perception on edu-

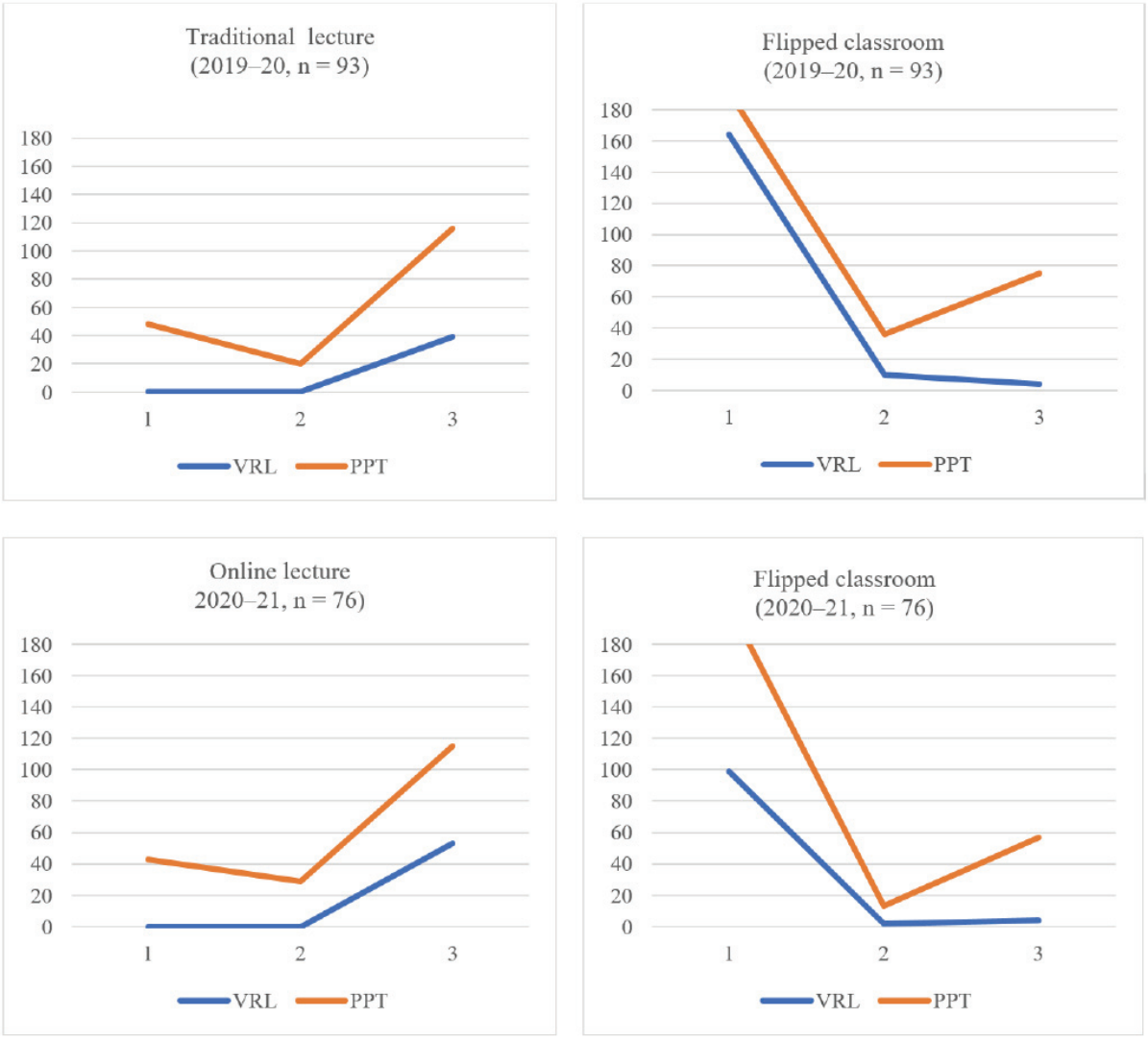

Figure 2. Statistics of students access to video's and PPT uploaded prior to FC and lectures.

cational gains that may be achieved by the flipped classroom. Students believed that FC helps them understand and remember concepts better than lectures. Thus, on both the sub-categories of reaction [13] including instruction method and educational gains, students reacted positively. Systematic reviews [6] and meta-analyses [7,14] across disciplines support the findings from our study that FC is perceived positively by students.

Typically, the F2F is an on-campus session but the COVID-19 pandemic forced these sessions to be online. Online teaching is complex with adaptations required from both: teacher and student. In the current study, faculty were oriented on adapting to online teaching by the medical education unit. The synchronous activities could be conducted online with Zoom. The quiz was conducted on Google Docs and results were displayed and discussed in real time. Breakout rooms were used for the case-based learning sessions to substitute the small group learning F2F sessions effectively.

The online sessions differed from the F2F session in two additional aspects: students had to prepare a concept map for the scenario and the session was allocated marks (2.5% of total marks for didactic component). Concept maps required students to apply their problem-solving skills to address the various possibilities arising from the case scenario.

Self-assessment activities (quiz) promote student engagement [7] and further enhance

the positive perceptions. Small group activities [15], introducing case scenarios [16] and concept maps [17] are both: individually and combined, part of the active learning activities known to enhance learning. The assumption that active learning strategies, 18 conducted in an appropriate way, are in major part responsible for the positive effects of flipped classroom [19], is reinforced by the enhanced student feedback for online FC as well. Nevertheless, apart from the active learning, other aspects such as the faculty orientation, student orientation, resource preparation, focused feedback may in varying degrees have contributed to the student's positive perception.

Unsurprisingly, a small number of students still preferred the lecture (either traditional or online). Moreover, students' scores were high on the opinion that they had to put more effort for the flipped classroom. A lecture mostly involves passive listening and flipped classroom requires students to take responsibility for their learning and hence requires a change in study practices. The reluctance may then be attributed either to resistance to change or a perceived need for instructor to explain the content. Nevertheless, this initial resistance has been reported to ease out over a period of time [20]. Thus, studies with evaluation over long term and larger scale of participation (entire courses and multiple courses in a program) are needed to evaluate if this subgroup can be better engaged by the flipped classroom.

Academic scores

The effect of FC on academic scores was evaluated by comparing historic scores on the selected topic (conducted as a lecture) with FC. The results from our study show that though the average scores were higher for FC, there is no significant difference in the scores between the traditional lecture and FC. The literature on effect of FC on academic scores has been mixed [12] with some reporting a significant increase with introduction of FC [21] while others reported no significant difference [22]. In the current study, the course had both didactic and clinical component, but the FC was implemented for the didactic part alone. It has been argued that the gains in academic scores may not be the appropriate means of measuring gains of FC [23] and the benefits are more measurable in terms of "gains in engagement with academic content, educators and peers, leading to strengthening of lifelong learning" [24].

Study practices

Students were asked prior to a lecture their willingness to read the uploaded resources before reporting to the session. Regardless of the expressed promise of utilizing the online resources prior to lecture, the percentage of students actually utilizing the resources was less than satisfactory. The study habits were further studied by accessing logs of activity on the LMS, Moodle.

During the period associated with FC, a sizeable number of students utilized the online videos with negligible use of PPT's. In the next phase, with no assessments, both video's and PPT usage fell drastically. In the consequent month, with the advent of a summative assessment, the online resource utilization spiked significantly, with a preference for PPT over videos.

Some of the inferences that could be drawn from the analysis are: (a) students' usage of online resources prior to a summative assessment, indicates a tendency to study only with the advent of an assessment(so called binge studying) [25]. Nevertheless, the introduction of FC coincided with increased student engagement with resources uploaded online, irrespective of FC (F2F) or FC online, as compared to the lectures. Even after accounting for the student motivation in FC online due to inclusion of scores in overall grades, the gains in student study practices by weaning them away from "binge studying" seems significant. (b) The introduction of videos/PPT for flipped classroom evinced a keen interest in student. Nevertheless, not more than 75% of the students used the resources. Hence the results of the quiz or assignment are even more important to gauge whether students are well prepared, with the knowledge component (c) Interestingly, the use of PPT was much higher immediately before the exam. This may be explained probably due to the convenience of converting these presentations into handouts and actually writing down notes.

Summary

The summary has been outlined based on Kirkpatrick's scale [26,27], measurable parameter and performance of FC.

Kirkpatrick's scale	Measurable parameter	Performance of FC
Reaction	Student's perception	Positive
Learning	Academic scores	No significant change from lecture
Behavioral change	Student study practices	**Needs more research:** Initial results showed increased utilization of resources by students associated with FC (a practice not noticed with lectures)

Conclusion

Successful student engagement is possible to be achieved even if the F2F session is converted to an online one, by engaging in meaningful active learning. The academic scores with Flipped classroom, online or with F2F, are at least equal to the ones achieved with a lecture. Student behavior of studying only with the advent of a summative assessment can be changed by introduction of FC. The asynchronous activities can be monitored on the LMS, and assurance of learning can be achieved by introduction of self-assessment with or without grading.

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Conflict of interest statement
The authors declare no conflict of interest.

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