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Designing flipped classroom using Kemp's instructional model to enhance deep learning and self-directed collaborative learning of basic science concepts

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Abstract:

BACKGROUND: The flipped classroom pedagogy allows students to introduce a topic and gather their own meanings outside of the classroom, then explore the topic and create their meanings or exclude their misconceptions during class. Our aim was to enhance the ability of self-directed learning (SDL) among medical undergraduates. Pedagogical benefits of the model are highlighted along with potential challenges to its use.

MATERIAL AND METHODS: Kemp's Instructional model was used to design flipped classroom. Need analysis was done to assess the perceptions of the students on the current teaching practices and their expectations for adoption of innovative methods. Validation of content was done by Delphi method by subject experts across the institutions. Content included objectives; case scenarios and extended multiple choice questions. Students were divided into two groups. Group A and Group B, 50 in each. A topic was given 1 week prior and both groups were subjected to a pretest to identify their self-study performance. Group A was exposed to 4 sessions of flipped classroom. They were provided with PowerPoint slides with voice recordings. In the classroom, first 30 min was meant for quiz and next 30 min was meant to clarify the doubts. Group B were exposed to the 4 regular lecture sessions. Both the groups were subjected to the posttest and test after 4 weeks. Later with another topic, flipped classroom was conducted for all the 100 students and the feedback was taken from all the students and faculty using a validated questionnaire.

RESULTS: Posttest scores of students who were flipped were statistically significant ($p < 0.001$). Most (98%) students opined that these interactive sessions evoked interest in the topic. Flipped classroom sessions were found to be effective in improving students' learning behavior toward SDL, collaborative learning skills and critically analyzing the basic concepts.

CONCLUSIONS: By following a systematic process (Kemp's instructional Model, it is possible to design need-based flipped classroom sessions. They are found to be effective in improving students' learning behavior toward deep learning, self-efficacy, SDL, collaborative learning skills, critically analyzing the basic concepts. In a flipped classroom, "the learning environment transforms into a dynamic and more social space where students can participate in critiques or work through problems in teams.

Keywords:

Collaborative learning, flipped classroom, Kemp's instructional model, self-directed learning

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Introduction

Self-directed learning (SDL) is an approach in which the learners feel and exercise authentic control over the content, form, and purpose of their own learning. SDL can appear in the classroom and by leveraging it as an integral part of how we learn, we can create a more meaningful learning experience for students that will last beyond the regurgitation of memorized content. This is in contrast to traditional lecturing which despite being an efficient method to present large amounts of content in classes of any size may result in students forgetting it soon due to passive listening. Redesigning the lecture using innovative teaching-learning approaches to engage students not only provides format change, but allows students to immediately apply content and provides feedback to the instructor on student learning. Medical Council of India has emphasized the introduction of Interactive Teaching Sessions in the curriculum. Exploring a teaching approach that uses technology to change the way class time is used to increase student engagement and performance through learning activities to achieve higher level understanding translates to time well spent. As curriculum requirements grow, instructors are pressured to make more efficient use of class time. In the flipped classroom, students can get the most "out of class time" in self-study and class time for practical application, that is not possible in a passive traditional lecture.^[1,2]

In conventional lecture, the sharing of resources is limited. Due to the time constraint it's difficult to plan group activities and discussions during the lectures. A combination of lecture and group discussions is the need of the hour. Technology is heavily emphasized by professionals in many medical schools abroad.^[3] It is less adopted in our country. Since in the flipped classroom model where lower cognitive domain knowledge content is learned before the class, it will have a considerable impact in education in a year or less because "the learning environment in the classroom, transforms into a dynamic and more social space where students can participate in critical thinking or problem solving in teams."^[3]

This model of pedagogy allows students to introduce a topic and gather their own meanings outside of the classroom, then explore the topic and create their meanings or exclude their misconceptions during in-class, through inquiry-based activities.

The flipped classroom is known by various names including the inverted classroom, and more simply, the flip. The flip evolved out of a history of experimentation with the concept of hybrid, or blended learning and problem-based learning, using active learning techniques

and new technologies to engage students. The flipped classroom has two defining components: moving the lecture outside of class, usually delivered through some electronic means, and moving the practical application assignments, (formerly "homework"), into the classroom.^[4] The Flipped Learning Network established four pillars of flipped learning that represent key practices in this model of teaching.^[5] They use the acronym "FLIP" to give an overview of these elements:

- F: Flexible environment
- L: Learning culture shift
- I: Intentional content
- P: Professional educators.

Strengths of the flipped model include efficient use of class time,^[2] more active learning opportunities for students,^[6] increased one-on-one interaction between student and teacher,^[7] student responsibility for learning, and addressing multiple learning styles.^[6,8] Each of these features has implications for student learning and may be more strongly or weakly demonstrated depending on the specific implementation.

Our aim was to induce SDL among medical undergraduates through flipped classroom. Our objectives were (a) to elicit the student's perceptions on current practice of teaching and assess their expectations with regard to teaching learning methods, (b) to develop and implement flipped classes for selected topics in Biochemistry among first MBBS students on pilot basis and then to the whole class of students, and (c) to assess the perception of students and faculty toward flipped classroom and evaluate the effectiveness of flipped classroom on academic performance of students in comparison with conventional lecture methods.

Materials and Methods

The study was conducted on first year medical undergraduates, in the department of biochemistry, after taking the institutional ethical clearance from July 2018 to September 2019. Informed consent from the students was taken and students who opted voluntarily were included into the study.

The study design is a "mixed method" study where qualitative (for need assessment) and quantitative methods (for establishing effectiveness of the intervention) were used in the "The Kemp's Instructional Design Model" (9 steps) that was used to design the flipped classroom. This is summarized in Figure 1. Student's perceptions (5 seniors who passed first year recently and 5 first year students) on the current teaching practices and their expectations for adoption of innovative methods (need analysis) – by free listing and pile sorting using visual Anthropac software. The

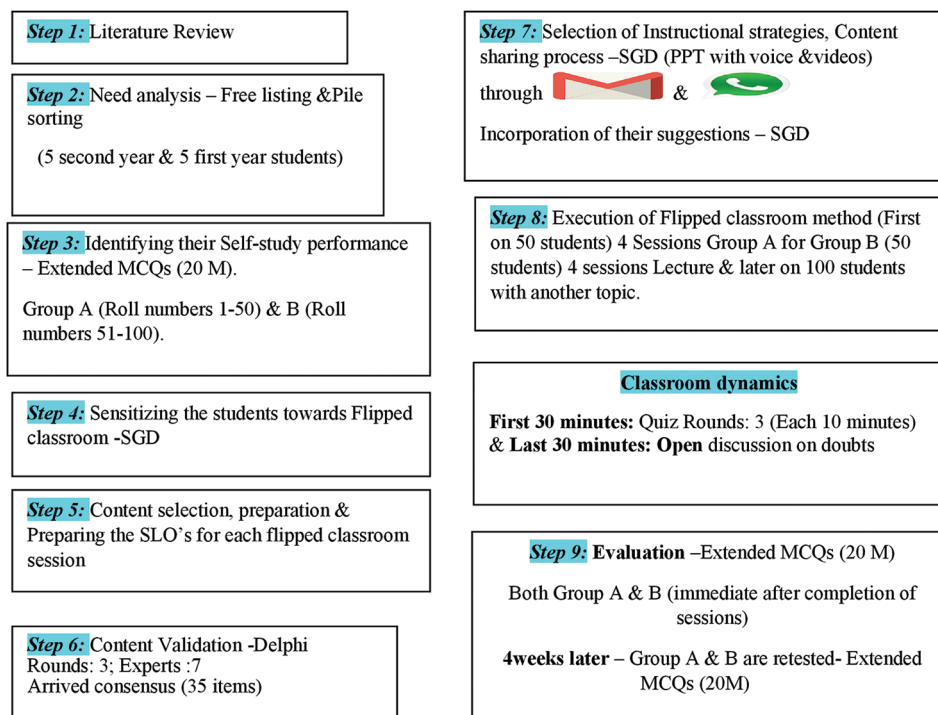


Figure 1: "The Kemp's Instructional Design Model" (9 steps)

free listing and pile sorting method has been adopted in different settings in the field of medicine.^[9-11] In short, these qualitative methods have been adopted to explore the cultural or the cognitive domains about any issue. We have applied this technique for need analysis. Free listing was to identify the perceptions of the students about the existing flaws and the suggestions that need to be incorporated to overcome the existing flaws in teaching learning methods. At the start of the interaction, a brief instruction was given to the participants about what is expected of them. The research questions were read to the participant one after the other, and it was ensured that they understand the question. Participants were given the option to record their responses on their own in writing. The responses obtained from the participants were analyzed using the Visual Anthropac software to identify those items which are prominent and representative of the cognitive domain. The Smith's Salience Score was calculated, and depending on the cut off observed, salient variables were selected for the next step of pile sorting. For the first research question, the perceptions of the students about the existing flaws in teaching learning methods, a total of 23 responses were obtained from ten respondents [Table 1], which were then fed into the Visual Anthropac software. A Smith Salience Score of <0.1 was taken as the cut-off and 17 salient variables (out of the 20 listed) were selected and eventually subjected to the second stage of pile sorting. For the second research question, suggested solutions for the flaws in the existing teaching learning

Table 1: Perceptions of the students about the flaws in existing teaching-learning methods

Item	Salience value
No student interaction	0.24
Monotonous	0.181
Difficult to concentrate for long time	0.143
Slide reading	0.261
No doubts clarification	0.181
No time to take notes	0.173
Understanding of students not checked	0.140
Fast pace of lecturer	0.130
Crowded ppt	0.101
Disturbance in class from last benches	0.112
Topic cannot be revised	0.106
Slow learners are not addressed	0.102
Lack of interest in ppt	0.123
Number of slides are more for a topic	0.102
No interactions during lecture	0.061
Lack of images, flow charts	0.004
Student participation is less	0.008

method, a total of 25 responses were obtained from 10 respondents [Table 2], which were then fed into the Visual Anthropac software. A Smith Salience Score of <0.1 was taken as the cut off and 15 salient variables out of 23 responses were selected and eventually subjected to the second stage of pile sorting.

Pile sorting was done to establish a relationship between the identified key aspects. The free pile sorting method was adopted for the current study where the pile sorting

was done on a one-to-one basis. The identified salient items were written on the cards (front side), while on the back-side numbers were mentioned to enable data entry. All the cards with the item name were placed in front of the participant and they were asked to group them together using their own criteria. Once the groups were formed, they were asked to explain why they grouped them in that particular way and their responses were recorded in the recording format. Also, each time, the pack of cards was shuffled before giving to the next participant. The participants were allowed to rearrange the piles. The obtained results or categories were again subjected to analysis using the Visual Anthropac software, and cognitive maps were drawn to identify a meaningful relationship between the salient variables. The first cognitive map [Figure 2] revealed the distribution of the flaws in the existing teaching learning methods. The other cognitive map [Figure 3] depicted the solutions for the flaws/expectations from the teaching learning methods.

Topic selection was done by discussing with department head and co faculty by one small group discussion session. The validation of content was done by Delphi method, taking the consensus from 7 experts.

Table 2: Suggestions by the students to overcome the flaws in existing teaching-learning methods

Item	Salience value
Sparing time for doubts clarification	0.352
Inclusion of activities after 30 min	0.142
Discussions to be increased	0.300
Break in between class after 30 min	0.155
Activities to be given for homework	0.183
Giving more stress to important points	0.133
Paying attention to every student	0.108
Revising the topics	0.140
Providing time to take notes	0.100
Slow learners to be addressed	0.121
Topic allotment prior to the class	0.104
Checking understanding of the student	0.111
Interactive lectures	0.102
Team building activities needed	0.033
Inclusion of case scenarios and videos	0.060

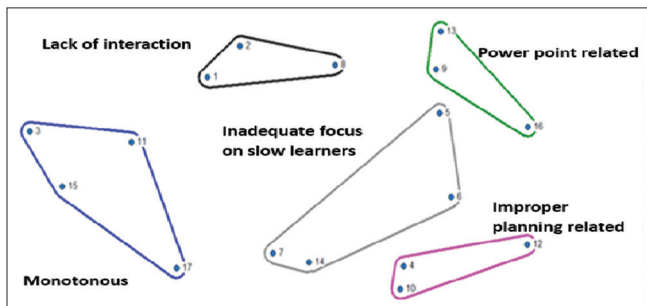


Figure 2: Cognitive map-flaws/views on existing teaching method

Three experts were from department of biochemistry (1 professor and head, 1 professor and 1 associate professor), other four experts were from different colleges. Content included objectives, case scenarios and extended multiple choice questions (MCQs). After 3 rounds a total of 35 items were finalized by the experts ($W = 0.4$). Kendall's coefficient of concordance test (W) was used to indicate the consensus reached by experts, represented in Table 3. Preparing the specific learning objectives (SLOs) for each flipped classroom session was done by two small group discussion sessions for half an hour each session. Suggestions from co faculty were incorporated. Students were divided into two groups. Group A (1–50 roll numbers students) and Group B (51–100 roll number students). Both the groups were given the topic "Hb metabolism" along with the SLO's 1 week before the sessions started. After 1 week both groups were subjected to a test with 20 extended MCQs to identify the prerequisite skills of the learner. Sensitizing the students toward flipped classroom was done by one session of small group discussion (for Group A–FC). Group A was exposed to 4 sessions of flipped classroom. These students were provided with the content of the topic and case scenarios in the form of PowerPoint slides with voice recordings. They were asked to come prepared for the class. In the classroom first 30 min students were engaged in quiz and next 30 min was meant to clarify their doubts. Quiz had 3 rounds. There were 5 teams and each team had 10 students. First round had total of 10 questions with each question having 1 min of time. There were no negative markings in this round. Rollover of the question was included. Each direct correct answer was awarded 20 marks and rollover correct answer with 10 marks. Second round had 10 questions, each correct answer was awarded 20 marks. There were no rollover questions and each wrong answer was given a negative marking of minus 10 marks. Final third round was a buzzer round. Whichever team presses the buzzer first will be allowed to answer the question. This round consisted of 10 questions; each correct answer was awarded with 20 marks. Wrong answer was given minus 10 marks, rollover correct answer was given

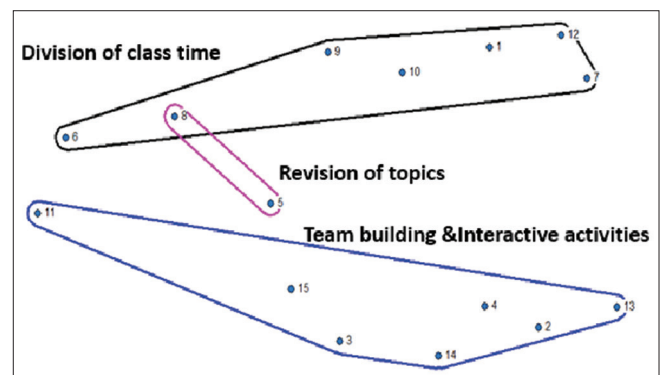


Figure 3: Cognitive map-solutions/expectations from teaching method

10 marks, and rollover wrong answer was given zero. Group B were exposed to the 4 regular lecture sessions on the same topic. Soon after the sessions both the groups were subjected to the post-test with 20 extended MCQs. Four weeks later, the two groups were subjected to the test with 20 extended MCQs to test their retention capacity and establish internal validity of the results and also possible contamination of effect of intervention in the control group. Pre- and post-test scores between both the groups were compared. Later a second topic on mineral metabolism was taken as a flipped session for all the 100 students. This is represented in Table 4. All the students [Figure 4] and the faculty [Figure 5] were subjected to a previously validated feedback questionnaire to assess the perceptions regarding the newer teaching-learning method (flipped classroom).

Results and Discussion

Tables 1-4 have been include below. Table 1: 17 Represents the salient variables from free listing, which are eventually subjected to the second stage of pile sorting. Table 2: Represents 15 salient variables from free listing, which are eventually subjected to the second stage of pile sorting. The cognitive map [Figure 2] revealed the distribution of the flaws in the existing teaching learning methods, into 5 categories namely lack interaction, monotonous lectures, inadequate focus on slow learners, improper planning and PowerPoint related issues. The cognitive map [Figure 3] depicted the solutions for the flaws/expectations from the teaching learning methods, in to 3 categories namely, division of class time, revision of topics, team building, and interactive activities. Table 3: Represents the validity and reliability scores of contents. Kendall's coefficient of confidence obtained was $W = 0.528$, indicating moderate

consensus obtained during Delphi technique among the panel experts. ($W > 0.7$ indicates strong consensus; $W = 0.5$ indicating moderate consensus, $W < 0.3$ indicates week consensus) Cohen's kappa coefficient of $K = 0.49$ and the reliability was tested by Cronbach's alpha $\alpha = 0.9$. Table 4: represents the test scores of Groups A and B. Pretest scores in the two groups A (4.76 ± 3.02) and B (4.58 ± 3.30) were similar ($p < 0.05$). Difference in the posttest scores between the two Group A (13.98 ± 3.04) and B (9.06 ± 4.01) were significant ($p < 0.001$)., showing the Group A who were exposed to Flipped classroom scored better than compared with the Group B, exposed to regular teaching method. There was significant difference ($p < 0.001$). Between the scores after 4 weeks between the two Groups A (13.58 ± 3.30) and B (8.52 ± 3.59). The Group A, exposed to flipped classroom scored significantly more than the other Group B, even after 4 weeks, indicating more retention capacity among Group A Figure 4: represents the perception of the students toward flipped classroom. On application of Kirkpatrick's Teaching effectiveness evaluation model.

Level 1: reaction-satisfaction and utility (responses on a 5-point Likert scale)

68% of students strongly agreed and 30% of students agreed that the understanding of the basic concepts improved after discussions; 68% students strongly agreed and 30% of students agreed that these interactive sessions evoked interest in the topic; 88% of students strongly agreed and 6% agreed that pre reading assignments were very helpful. 88% strongly agreed and 8% agreed that they had spent more time for preparation of SDL sessions.

Level 2: Knowledge-improvement Academic performance

Scores of pretest before the module were similar among both groups. Scores of Test 2 after the Flipped classroom

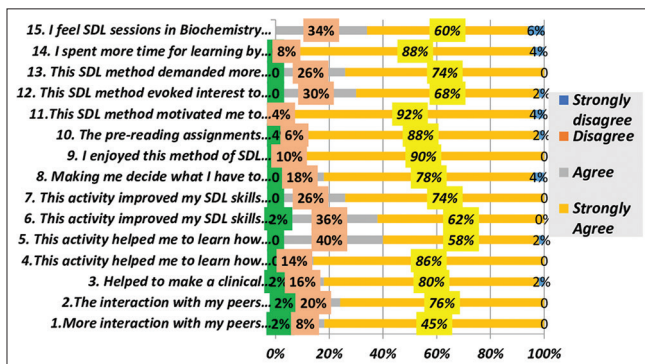


Figure 4: Percentage bars -perceptions of students toward flipped classroom technique

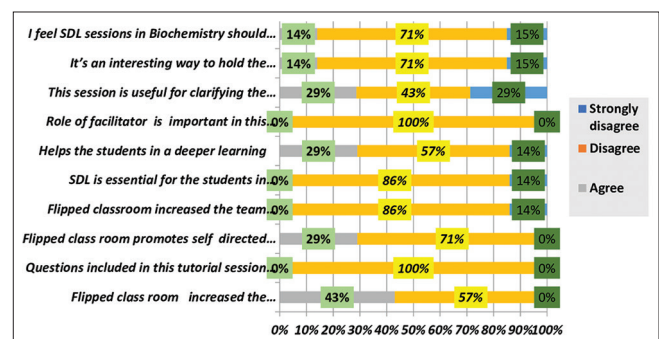


Figure 5: Percentage bars -perceptions of faculty towards flipped classroom

Table 3: Validity and reliability scores of content and assessment tools

Items	Kendall's coefficient of concordance	P	Cohen's kappa coefficient	Reliability Cronbach's alpha
Round 3	$W=0.528$ Moderate	<0.005	$K=0.49$	$\alpha=0.9$

Table 4: Test scores of Group A and Group B

Groups	Mean±SD	p
Pretest A	4.76±3.02	<0.005
Pretest B	4.58±3.30	
Posttest A	13.98±3.04	<0.001
Posttest B	9.06±4.01	
4 week A	13.58±3.30	<0.001
4 week B	8.52±3.59	

SD=Standard deviation

showed significant improvement (posttest A - 13.98 ± 3.04 in intervention group compared to posttest B of 9.06 ± 4.01) in the control group ($p < 0.001$).

Level 2: Learning skills-changes in learning strategy

All students (100%) agreed that there was increased Collaborative learning skills (with 74% of students strongly agreeing). Similarly, 86% of students strongly agreed and 14% of students agreed that there was increase in their SDL learning skills (how to perform literature search, and prepare for SDL session); also, most (96%) of students agreed (and 80% agreeing strongly) that there was increase in their analytical thinking levels and clinical reasoning skills. Our findings were similar to the findings in a study by Bennett *et al.*^[12] He described the characteristics of effective flipped classroom as discussions are led typically reached higher orders of critical thinking, content given to students relates to real world scenarios, thus giving a challenge to the students. This led to student's tutoring and collaborative learning forms simultaneously. Students ask exploratory questions and have the freedom to delve beyond core curriculum. Students are actively engaged in problem solving and critical thinking that reaches beyond the traditional scope of the content. Students transform from passive listeners to active learners. Figure 5 shows the perceptions of faculty toward the newer teaching method.

All faculty (100%) agree (with 57% of them strongly) that flipped classroom increased the student's interest on the subject. Similarly, all (100%) faculty agree (86% strongly) agreed that flipped classroom increased team-building among the students. All (100%) faculty strongly agreed that role of facilitator is crucial during flipped classroom sessions. Majority (71%) of faculty strongly agreed and 14% agreed that flipped classroom sessions help to hold the concentration of the students for a longer time. About 15% of faculty disagreed to this. Furthermore, majority (85%) agree (71% strongly) to conduct SDL session in this same manner. In addition, all (100%) agree (with 86% strongly) that flipped classroom promotes SDL among students and this is essential for students right from first year.

We could pick up a few advantages of flipped classroom which matched with the study conducted by Fulton, Goodwin, and Millerand. The classroom time can be used effectively used for interactive sessions. By means of lecture videos the teacher uses the time for the interaction between teacher and student rather than for teaching. Accordingly, the teacher can spare more time to fulfill the learning and emotional demands of students.^[13,14] In flipped classroom approach the students can find opportunity to discuss with their teachers which is not a possible situation in traditional approach.^[15] The most important benefit of flipped classroom approach is to support team working within class. The students learn at their own speed. The students that are educated with this approach are encouraged to think both within and out of class.^[16,17] Flipped classroom approach provides students more time to make inventive research.^[18] Despite all these positive sides, we had few negative opinions about the method. Students may be stubborn at the beginning and may come to class without preparation. Also, lecture videos should be prepared carefully in a way to prepare students for the course. It is hard to prepare such good quality videos and it takes time. Our findings matched with Herried in this study on flipped classroom.^[18] There is always uncertainty for the teachers about how the students do their responsibilities out of class well. Also, some limitations for this approach was expressed as students lacking smartphones, tablets and having some internet problems. The biggest disadvantage for teachers is not preparing or broadcasting lecture videos but preparing within class activities and integrating them to flipped classroom approach. In contrast to what is known, this method increases the duty of teachers instead of relieving.^[19,20] Flipped classroom can be a good option if colleagues are interested in promoting interactive questioning, content and idea exploration and ensure that students take more control of their own learning. Preparing the instructional resources requires effort and time.^[13] Although introducing flipped classroom can mean additional work initially but gives a way to acquire new skills. We can go ahead initially implementing the flipped classroom for selected sessions in the course until we develop enough confidence and time to flip the major amount of course. In order to compensate the educational demands of students, it is important to use innovative approaches in education. The number of researches regarding this approach is just a few and this makes us think that the approach is not well known. This study can attract attention of educators about the potential of approach and can form a point of view how to use it in their courses. For expanding of flipped classroom approach in educational institutions, it is thought that the approach has to be cognitively and practically presented. Accordingly, the skills of teachers in designing materials by using multiple teaching tools/techniques and to transform these materials with

learning management systems, have to be developed. The positive development in desire, interest and motivation of educators using technological equipment will be effective in spreading of this approach. In future studies the applications of flipped classroom approach in different education levels can be investigated.

Conclusions

With systematic approach and planning, it is possible to design and implement Flipped classroom sessions. They are found to be effective in improving students learning behavior toward deep learning, self-efficacy, SDL, collaborative learning skills, critically analyzing the basic concepts. A flipped classroom is a model that will have a considerable impact in education in a year or less because "the learning environment transforms into a dynamic and more social space where students can participate in critiques or work through problems in teams.

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Conflicts of interest

There are no conflicts of interest.

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