Effectiveness of Flipped Learning Instructional Pedagogy on Learning Engagement and Academic Achievement in Chemistry

VANDANA M* AND HASEEN TAJ**

Abstract

Innovative pedagogies of the digital age attempts to abandon the passive teacher centred one way teaching process involving students actively to facilitate learning, thus improving the teaching-learning process. Flipped instruction is a digital pedagogy which has brought drastic changes in the teaching-learning process which reverses the traditional learning environment and students invest their time and effort in both synchronous and asynchronous sessions. Hence, in this experimental study the researcher attempted to investigate the effectiveness of flipped instruction on students' learning engagement and academic achievement by collecting data from Grade IX students and the analysis showed that there is significant difference in Learning Engagement and Academic Achievement in Chemistry of students who were taught using flipped learning instruction and traditional learning, further, the students taught with flipped learning instruction had better learning engagement and higher achievement scores compared to the students taught with traditional learning mode.

INTRODUCTION

Education is dynamic in nature, the teaching-learning process is influenced by the changes happening in society and the needs of the learner. Modern society is working on the digital system.

In this digital era, many innovative pedagogies have aroused to improve the teaching-learning process

**Research Scholar,* Department of Education, Bangalore University, Bengaluru.
***Chairperson,* Department of Education, Bangalore University, Bengaluru.

according to the needs of modern digital society. Innovative pedagogies attempt to abandon the passive teacher centre one way teaching process instead involving students actively and facilitate learning. This shifts the role of teachers to a facilitator, a guide and students to knowledge creators by interacting with themselves and teachers actively and exploring the content in depth. Flipped instruction is a digital pedagogy which has brought drastic changes in the teaching-learning process. Flipped learning is an approach which transform the traditional teaching-learning environment and shifts the one way classroom teaching-learning to asynchronous pre learning sessions in which learners put their time and effort in understanding the basic learning and remember those learning elements which are required to work collaboratively among peers to explore their knowledge in depth.

Rationale of the Study

Earlier the teaching-learning process was mostly confined inside the classroom and learning of students was not monitored by the teacher out of the classroom. Flipped instruction attempts to change this scenario and monitors learners throughout the learning journey. It allows teachers to blend various methodologies in their classroom and monitor the learning of the students both in synchronous and asynchronous sessions. Synchronous sessions happen when both students and teacher meet regularly inside the classroom for instructional process. It is the face to face learning situation in which a teacher meets their students physically and involves all students in learning through various strategies in which students collaborate with each other actively.

Asynchronous sessions happen at the pace, place and time of students in which students view the digital pre-learning materials provided and complete the learning tasks created by the teacher. Both teachers and learners are connected via a digital network to access the digital learning resources. The asynchronous session happens in two phases—before the class session and after the class session. Teachers connect to their learners before the class session via a suitable digital network to provide necessary inputs for their learning. These learning resources are designed to prepare the learners for their face to face in-class sessions, few learning tasks to check the prior knowledge of the learners and to provide new knowledge at lower order thinking skills. This pre-learning asynchronous session creates rapport between teacher and learner with the content to be explored in their in-class sessions. It stimulates the learners to explore the content in depth.

Flipped learning instruction is an educational technique that consists of two parts—Interactive group learning activities inside the classroom and direct computer based

individual instruction outside the classroom. Students are assigned the video watching for home work, freeing up class time that is used to be spent listening to lectures for hands on activities and application of knowledge which used to serve as home work. Flipped learning instruction employs group based interactive learning activities inside the classroom.

Teachers and students connect with each other after every in-class session through the same digital network to continue their learning discussions. This gives opportunities for teachers to engage their students outside the classroom by involving them in learning activities which sustains students' interest and motivation. Teacher provides post-learning activities to students to assess their progress in learning. This happens at the pace of students and increases their retention. This post-learning asynchronous session engages students in learning activities to stimulate students' intellect and students seek to go beyond the requirements through the post-learning activities.

According to Flipped Learning Network 2014, effective flipped learning instruction involves four pillars — flexible environment, learning culture, intentional content and professional educator. Michele Estes et al (2013) propose a simple model for flipping the classroom with three stages — pre-class, in-class, and post-class.

Stages of Flipped Learning Instruction

Pre-class

The flipped instructor will move this type of activity to an asynchronous learning environment. If the information is available online, students may read and refer to it as often as needed in order to recognise and recall it later. Procedural instruction that changes very little with time is also appropriate for the asynchronous learning environment. Instructors design their original, pre-recorded digital learning materials in a variety of media formats to provide as pre-learning resources (Mazur, 2009). In this step, instructors have the opportunity to asses student knowledge in advance of class-time to identify areas that require clarification or emphasis during class time. By understanding student needs prior to class instructor will make adjustments required during in-class.

In-class

During synchronous learning of the flipped classroom, the instructor uses activity-based learning strategies to maximise student-teacher interaction on learning content through in-class discussion, group learning and individual learning activities, observation of students while performing any experiments, and potentially the use of technologies to conduct formative assessment such as learner response systems.

Student-student engagement is very important in flipped classroom. Adopting peer feedback and peer instruction during in-class time is very essential to explore the content in depth and practice. Maximising the instructor-student and student-student interaction during in-class is regarded as essential ingredient in teaching-learning process. The features of technology can be used as a lever to make it happen effectively.

Post-class

Before and after the asynchronous and synchronous components of flipping have occurred, instructors in the flipped classroom have an opportunity to increase student attention and sustain student motivation for engagement in learning outside of class time, and to assess learner progress through post-class learning activities. Instructors who flip their classroom incorporates extrinsic motivators that encourage advance preparation. Adoption of technologies that shift the role of instructor to that of learning coach will support the development of students' self-regulation skills necessary for success in flipped environment. A variety of methods and tools of assessment available are used to assess student learning after instruction.

Flipping the teaching-learning process became more popular and influenced by the inverted classroom approach as evidenced from the study conducted by Lage et al (2000) and this approach maximises active learning by using a variety of media and delivery modes of content to develop self-regulated learning among students during the pre-class sessions (Talbert, 2014) and instruction employed by Mazur (2009) to engage students actively during the synchronous in-class sessions. Novak and Patterson (1998) states synchronous in-class sessions as a way of combining collaborative course work with online materials and activities to help instructors understand student needs to offer timely feedback and plan the lessons responsive to the needs of the learner.

The reviews collected were analysed and the reveals that flipping the teaching-learning process enhances critical thinking of students thereby increasing learning engagement and achievement of students (Kaur, 2018). Flipped learning integrates active learning to increase achievement of students (Eichler, Peeples, 2016) and activates higher order thinking skills to engage students in learning. It also ensures that students remain at Higher order thinking levels for longer duration (Bormann, 2014) and creates friendly classroom environment (Borkar, Turkar, and Borkar, 2017). Flipped learning allows all students to attain the set objectives overcoming their learning problems (Fornasari, 2015). Flipped learning attempts to increase students learning engagement (McLaughlin et al, 2014) and performance as a result of active

learning strategies conducted during synchronous sessions (Carlson and Winquist, 2011)

As evident from above, student involvement in the learning process and achievement in learning increases by incorporating letter learning as an instructional process. This reverses the traditional learning environment and students invest their time and effort in both synchronous and asynchronous sessions of flipped learning therefore the researcher attempted to investigate the 'Effectiveness of Flipped instruction on Students' Learning Engagement and Academic Achievement'.

Objectives

1. To compare the effect of flipped learning instruction with traditional learning on students' learning engagement.
2. To find out the difference in learning engagement of students who were taught using flipped learning instruction and traditional learning.
3. To find out the difference in academic achievement in chemistry of students who were taught using flipped learning instruction and traditional learning.
4. To find out the difference in progressive tests in chemistry of students who were taught using flipped learning instructional pedagogy and traditional learning pedagogy.
5. To investigate the main and interaction effect of teaching methods and gender on students' learning engagement from control and experimental groups.
6. To investigate the main and interaction effect of teaching methods and gender on academic achievement in chemistry of students from control and experimental groups.

Hypotheses of the Study

1. There is no significant difference between the control group and experimental group's pre-test scores of learning engagement.
2. There is no significant difference between the control group and experimental group's post-test scores of learning engagement.
3. There is no significant difference between the pre-test and post-test mean scores of learning engagement of experimental group of students.
4. There is no significant difference between the pre-test and post-test mean scores of the learning engagement of control group of students.
5. There is no significant difference between the control group and experimental group's pre-test scores of academic achievement in chemistry.
6. There is no significant difference between the control group and experimental group's post-test scores of academic achievement in chemistry.

7. There is no significant difference between the pre-test and post-test mean scores of academic achievement in chemistry of experimental group of students.
8. There is no significant difference between the pre-test and post-test mean scores of academic achievement in the chemistry of control group of students.
9. There is no significant difference between the experimental group and control group's mean scores of progressive test 1 in chemistry.
10. There is no significant difference between the experimental group and control group's mean scores of progressive test 2 in chemistry.
11. There is no significant main and interaction effect of teaching methods and gender with each other on students' learning engagement.
12. There is no significant main and interaction effect of teaching methods and gender with each other on academic achievement in chemistry.

Methodology

The researcher selected experimental method for conducting the research with flipped learning instructional pedagogy as an independent variable which affect the dependent variables like learning engagement and academic achievement in chemistry of students.

Operational Definitions

Flipped learning instructional pedagogy can be operationally defined as an instructional approach in which secondary school students gain basic knowledge of the chosen content in-home or in any other place through asynchronous video lectures, pictures, animations, simulations, and text. An interactive learning environment is created during in-class time by engaging students with activities, real demonstrations, discussions, and group activities prepared by the researcher to assist them in applying the concepts learned in their home during pre-class activities to those activities conducted during class-time.

Students' learning engagement can be operationally defined as an interactive engagement in which students are engaged actively individually as well as in small group to analyse, synthesise and evaluate the subject matter with the guidance given by the researcher both in the face-to-face class and online instruction.

Achievement scores in Chemistry of the students exhibit a link with the method used for instruction, which fosters a change in student achievement in Chemistry. In this present study, it refers to the students' score on the achievement test in chemistry developed by the researcher.

Sample

The study utilised a sample of 60 students of Grade IX in an English medium government school located in Bangalore urban. The present experimental study utilised pre-test post-test two group design. Thirty students were having the facility of accessing digital devices after school hours to view the digital learning resources for participating in pre-class activity and to complete digital assignments for post-class activity, they were selected and grouped as the experimental group and the students who did not have the facility of accessing digital devices after school hours were grouped as the control group. Thus, the study utilised purposive sampling in which both experimental and control groups consisted of 30 students each.

Tools Used in the Study

Learning engagement scale (5 point attitude scale with 42 items) and academic achievement test in Chemistry (34 MCQs in the content taught) constructed and standardised by Vandana M. and Haseen Taj (2019) were used for collecting pre-test and post-test scores for research data. The reliability of the above tools were found to be 0.871 and 0.97 respectively. Also research developed two unit tests in Chemistry (for the content taught) which were used as progressive tests.

Research Design

The present experimental study employed pre-test and post-test group design. Both control and experimental groups of students were administered with a pre-test using learning engagement scale and academic achievement test in Chemistry. One unit from the Chemistry part of Science text book for Grade IX was taught to both experimental and control groups of students. The experimental group of students were trained to access moodle platform to complete their out of class activities. Out of class activities for flipped instruction consisted of a variety of digital resources like videos, text, infographics, animations on the lesson taught as pre-learning resources and digital assignments as post-class activities. After pre-class session synchronous face to face sessions inside the classroom was conducted by utilising group and individual active learning strategies in which students participated in both digital and non-digital activities. The lecture and demonstration method was used to teach the same unit for students of the control group. During classroom teaching relevant teaching-learning aids like charts and models were shown to students and questions were asked to interact with students to clarify their doubts. The duration of teaching for both the experimental and the control groups of students was 50 days. Progressive tests on the unit were administered to both control and experimental

group of students on the 25th and 50th day. After the completion of teaching and progressive tests, both experimental and control groups students were administered with post-test in learning engagement and the academic achievement test in chemistry using the tools constructed by researcher.

Findings

The data on pre-test and post-test scores on learning engagement and academic achievement in Chemistry, progressive tests 1 and 2 in Chemistry were analysed using t-test and the findings of the analysis were tabulated as below.

Table 1
Table Showing Pre-test, Post-test Mean Scores of Learning Engagement between Experimental and Control Groups

Groups	N	Mean	SD	t-value	Level of Significance
Pre-test on Learning Engagement					
Experimental	30	164.07	15.970	0.405	NS
Control	30	165.63	13.912		
Post-test on Learning Engagement					
Experimental	30	185.67	10.877	2.396	*
Control	30	178.63	11.836		
Learning Engagement of Control group of Students					
Pre-test	30	165.63	13.912	8.900	**
Post-test	30	178.63	11.836		
Learning Engagement of Experimental group of Students					
Pre-test	30	164.07	15.970	11.764	**
Post-test	30	185.67	10.877		

*NS = Not Significant, * = Significant at 0.05 level, ** = Significant at 0.01 level*

Table 2
Table Showing Pre-test, Post-test Mean Scores of Academic Achievement Test in Chemistry between Experimental and Control Groups

Groups	N	Mean	SD	t-value	Level of Significance
Pre-test on Academic Achievement test in Chemistry					
Experimental	30	4.83	1.085	2.068	*
Control	30	4.33	0.758		

Post-test on Academic Achievement Test in Chemistry					
Experimental	30	27.4	2.99	12.517	**
Control	30	18.23	2.674		
Academic Achievement Test in Chemistry of Control Group of Students					
Pre-test	30	4.33	0.758	26.877	**
Post-test	30	18.23	2.674		
Academic Achievement test in Chemistry of Experimental group of Students					
Pre-test	30	4.83	1.085	35.921	**
Post-test	30	27.4	2.99		

*NS = Not Significant, ** = Significant at 0.01 level*

Table 3
Table Showing Mean Scores of Progressive Tests 1 and 2 in Chemistry of Experimental and Control Groups

Groups	N	Mean	SD	t value	Level of Significance
Progressive Test 1 in Chemistry					
Experimental	30	19.53	3.501	7.184	**
Control	30	13.0	3.545		
Progressive Test 2 in Chemistry					
Experimental	30	19.23	3.901	7.180	**
Control	30	12.6	3.223		

*** = Significant at 0.01 level*

The data on post-test scores on learning engagement of students from both the experimental and the control groups were analysed using 2 way ANOVA and the findings were as shown in the Table below.

Table 4
Showing Observed Data for 2 Way ANOVA of Teaching Method of Boys and Girls of both Groups

Teaching Method		Traditional Learning	Flipped Learning
Gender			
Boys	N	16	12
	Mean	180.19	187.67
	Standard Deviation	10.815	10.815
Girls	N	14	18
	Mean	176.86	184.33
	Standard Deviation	13.085	11.019

Table 5
Results of 2 Way ANOVA for Learning Engagement with Independent Variables Namely, Gender and Teaching Method

Sources of Variation	Sum of Squares	Df	Mean Squares	F – Value	Level of Significance
Gender	162.764	1	162.764	1.243	NS
Teaching Method	819.825	1	819.825	6.263	**
Interaction of Gender and Teaching Methods	3.247	1	3.247	0.00	NS
Error	7330.818	60			
Total	8235.650	59			

Table 6
Showing Observed Data for 2 Way ANOVA of Teaching Method of Boys and Girls of both Groups

Teaching Method		Traditional Learning	Flipped Learning
Gender			
Boys	N	16	12
	Mean	18.13	27.42
	Standard Deviation	2.217	2.678
Girls	N	14	18
	Mean	18.36	27.40
	Standard Deviation	3.201	3.256

Table 7
Results of 2 way ANOVA for Academic Achievement in Chemistry with Independent variables namely, Gender and Teaching Method

Sources of Variation	Sum of Squares	Df	Mean Squares	F – Value	Level of Significance
Gender	0.153	1	0.153	0.018	NS
Teaching Method	1230.667	1	1230.667	147.841	**
Interaction of Gender and Teaching Methods	0.248	1	0.248	0.030	NS
Error	466.159	60	8.324		
Total	1726.983	59			

Discussion of Results

From Table 1, it is observed that the obtained t-value of 0.405 is less than 2.000 at 0.05 level; this infers that both experimental and the control group of students have the same learning engagement before the treatment, hence the Hypothesis 1, there is no significant difference between the control group and the experimental group students in their mean scores of pre-test in learning engagement is accepted. There is a significant difference between the experimental and the control group students in their mean scores of post-test in learning engagement, it is observed that the obtained t-value of 2.396 Is greater than the table value of 2.000 at 0.05 Level. Thus, both experimental and the control groups significantly differ in their mean scores of post-test in learning engagement, further it is observed that students from the experimental group have higher levels of learning engagement than the students from the control group, hence Hypothesis 2 is rejected. This result is similar to the findings of the research conducted by Maheshwari and Seth (2019) that students' learning engagement improves with the implementation of flipped learning and students feel highly satisfied (Awidi and Paynter, 2019). It is also observed that the obtained t-values of 8.900 and 11.764 are greater than the table value of 2.660 at 0.01 level, hence Hypotheses 3 and 4 are rejected and it can be restated as there is significant difference between the pre-test and post-test mean scores of the learning engagement of the control group of students and there is significant difference between the pre-test and post-test mean scores of the learning engagement of the experimental group of students. It also reveals that the learning engagement of the students increased after the treatment for both experimental and the control groups of students, further the value of 11.764 is greater than the value of 8.900, thus students of the experimental group have better learning engagement than the students of the control group. This result is in agreement with the results obtained by Hernández, (2012) that flipped learning increases students' learning engagement and students involved in interactive learning activities by investing their time before and during the classroom learning as shown by Webb et al (2014).

From Table 2, it is observed that the obtained t-value of 2.068 is slightly greater than the table value of 2.000 at 0.05 level and the hypotheses 5 is rejected and stated as there is significant difference between the control group and experimental groups pre-test mean scores of academic achievement in chemistry, the obtained t-value of 12.517 is very much greater than the table value of 2.704 at 0.01 level and hence Hypothesis 6 is rejected and restated as there is significant difference between the control group and experimental groups

post-test mean scores of academic achievement in Chemistry. Future, it is observed that the t-value of 12.517 of post-test mean scores is higher than that value of 2.068 of pre-test mean scores hence it reveals that the flipped learning instruction has great influence on academic achievement of students. Flipped learning increases academic achievement of students (Alamri, 2019) and significantly higher scores in achievement for experimental students was observed (Özüdoğru and Aksu, 2020). It is also observed that the obtained t-value of 26.877 and 35.921 are greater than the table value of 2.704 at 0.01 level hence, Hypothesis 7 and 8 are rejected and restates as there is significant difference between the pre-test and post-test mean scores of academic achievement in Chemistry of control group of students and there is significant difference between the pre-test and post-test mean scores of academic achievement in Chemistry of experimental group of students. It is also observed that the post-test mean scores of academic achievement in Chemistry are higher than that of the pre-test mean scores, further the obtained t value of 35.921 of experimental group is more than the value of 26.877 of control group students. This result suggests that the students taught with flipped learning instruction have obtained higher scores in academic achievement than the students who were taught using traditional learning pedagogy. Flipped instruction incorporates active learning strategies and ensures students to remain at higher order thinking levels for a longer time (Bormann, 2014). The academic performance of students improves by incorporating flipped instruction (Bueno–Alastuey and Galar, 2017) and increases academic achievement of students (Vimala and Muniandy, 2018).

From Table 3, the obtained t-values of 7.184 and 7.180 are greater than the value of 2.704 at 0.01 level hence Hypotheses 9 and 10 are rejected and restated as there is significant difference between the control group and experimental groups mean scores of progressive test 1 in Chemistry and there is significant difference between the control group and experimental groups mean scores of progressive test 2 in Chemistry. Flipped learning enhances academic achievement of students (Kaur and Gurpreet 2018) and integrates active learning into chemistry courses (Eichler and Peeples, 2016).

From Table 5, it is observed that gender has no significant main effect ($f = 1.243$, $P > 0.05$) on learning engagement of students, teaching method (traditional teaching and flipped learning) has significant main effect ($f = 6.263$, $P < 0.01$) on learning engagement of students and there is no significant interaction effect of gender and teaching method ($f = 0.00$, $P > 0.05$) on learning engagement of students. The result infers that gender has no significant effect on learning engagement and

teaching method has a significant effect on learning engagement. Further, flipped learning increases students' concentration (Kurushkin, M., and m., Mikhaylenko, 2016), student understanding and self-determination (Calderara and Wiebe, 2019) on watching pre-learning videos.

From Table 7, it is observed that gender has no significant main effect ($F = 0.018$, $p > 0.05$) on academic achievement in chemistry of students, teaching method (Traditional Teaching and Flipped Learning) has significant Main effect ($F = 147.841$, $p < 0.01$) on academic achievement in chemistry of students and there is no significant interaction effect of gender and teaching method ($F = 0.030$, $p > 0.05$) on academic achievement in chemistry of students. The result infers that gender has no significant effect on academic achievement in Chemistry and teaching method has a significant effect on academic achievement in Chemistry. Further, flipped learning increases academic achievement of students as students derive learning satisfaction (Lopes and Soares, 2017) and in-class group activities attempt to clarify their doubts (Borkar, Turkar, and Borkar, 2017) and students attain the set objectives (Fornasari, 2015).

Educational Implications

Flipped learning instruction shifts direct instructional process from synchronous to asynchronous sessions and incorporates active learning strategies during synchronous sessions to involve every learner. The results reveal that there is significant difference in post-test in the learning engagement of experimental and control group of students further, the mean value of 185.67 of the experimental group is greater than that of 178.63 of the control group of students, hence teachers should design learning activities to involve all students in the learning process. The result shows that there is significant difference in pre-test and post-test mean scores of learning engagement of the experimental group of students. Further, the mean value of 185.67 of post-test in learning engagement is greater than the mean value of 164.07 of pre-test in learning engagement of the experimental group of students. It is higher than the post-test mean scores of 178.63 of the control group of students. Thus teachers should implement flipped learning instruction in their pedagogical practices and incorporate both synchronous and asynchronous learning sessions in their teaching process.

The post-test mean scores of academic achievement in chemistry of experimental and control groups differ significantly, further, the mean value of 22.7 of the experimental group is more than the mean value of 18.23 of the control group. This implies that flipped learning has enhanced mean scores in academic achievement in chemistry of an experimental group

of students hence teachers should create e-content on the topics to be taught and provide to their students to engage in pre learning activities.

The results reveal that there is significant difference in progressive test 1 of experimental and control group of students, further, the mean value of 19.53 of experimental group is a more than the mean value of 13.0 control group of students. Also there is significant difference in progressive test 2 of experimental and control group of students. Further the mean value of 19.23 of experimental group is greater than the minimum value of 12.6 of control group of students. Hence, teachers should design learning activities to involve all students in the learning process to engage them in collaborative work with peers. Teachers should plan the in class activities so that there is more time available for interaction with students and facilitate them to explore the highest knowledge possible.

Conclusion

Technology has influenced the teaching-learning process and resulted in development of modern pedagogical practices. Flipped learning instructional pedagogy is one such innovative pedagogy which attempts to involve students and teachers in synchronous and asynchronous teaching-learning sessions. Flipped learning instructional pedagogy provides lot of opportunities for teachers to create learning resources and activities to involve their students in learning process as well as to spend more in-class time for fruitful interaction with their students and develops self-learning and deep learning skills among students to increase their interest and achievement in learning. Thus it can be concluded that flipped learning instructional pedagogy maximises classroom interaction to increase students' learning engagement and thereby increase in academic achievement and performance of students.

References

Alamri, M. M. 2019. Students' academic achievement performance and satisfaction in a flipped classroom in Saudi Arabia. *International Journal of Technology Enhanced Learning*. Vol. 11, No. 1. pp. 103–119. https://doi.org/10.1504/IJTEL.2019.096786

Awidi, I. T., and M. Paynter. 2019. The impact of a flipped classroom approach on student learning experience. *Computers and Education*. https://doi.org/10.1016/j.compedu.2018.09.013

Borkar, S., V. Turkar, and Y. Borkar. 2017. The essence of traditional teaching methodology over web based learning–traditional vs. Flipped classroom teaching method. *38th Asian Conference on Remote Sensing–Space Applications: Touching Human Lives, ACRS 2017, https://a-a-r-s.org/proceeding/ACRS2017/ID_753_1652/1477*.

Bormann, J. 2014. *Affordances of Flipped Learning and Its Effects*. 38. Retrieved from http://flippedlearning.org/cms/lib07/VA01923112/Centricity/Domain/41/bormann_lit_review.pdf

Bueno-Alastuey, C., and I. A. Galar. 2017. Flipping the EFL classroom in a secondary education setting: Students' perceptions and academic performance. *Huarte de San Juan. Filología y Didáctica de La Lengua*. Vol. 17. pp. 35–57.

Calderara, S. J., and E. Wiebe. 2019. *'Activating Learning and Motivation in Undergraduate general Chemistry by Flipping the Classroom: A Mixed Methods Study*'. In Thesis submitted to The graduate Faculty of North Carolina State University.

Carlson, K. A., and J. R. Winquist. 2011. Evaluating an active learning approach to teaching introductory statistics: A classroom workbook approach. *Journal of Statistics Education*. Vol. 19, No. 1. pp. 1–23. https://doi.org/10.1080/10691898.2011.11889596

Eichler, J. F., and J. Peeples. 2016. Flipped classroom modules for large enrollment general chemistry courses: A low barrier approach to increase active learning and improve student grades. *Chemistry Education Research and Practice*. Vol. 17, No. 1. pp. 197–208. https://doi.org/10.1039/c5rp00159e

Estes, M. D., R., Ingram, and J. C. Liu. 2015. *A Review of Flipped Classroom Research Practice and Technologies*. The Higher Education Teaching and Learning Portal, 2015 Utah, 1–10. Retrieved from https://www.hetl.org/a-review-of-flipped-classroom-research-practice-and-technologies/

Fornasari, A. 2015. Ict and Innovative Teaching. How To Build Skills for Generating Web 2.0 With Flipped Learning. a Case Study Itis Majorana of Brindisi. *International Conference RCIC' 15 Redefining Community in Intercultural Context, Rcic'15*. Vol. 4 (May). pp. 265–271.

Hernández, R. 2012. Collaborative Learning: Increasing Students' Engagement Outside the Classroom. *US-China Education Review*. Vol. 9. pp. 804–812.

Kaur, Gurpreet. 2018. Effect of Flipped Classroom model and Problem Solving strategies on Achievement and Student Engagement in Mathematics in relation to Critical Thinking. Thesis submitted to Punjab University, India. http:hdl.handle.net/10603/235168

Kurushkin, M., and M. Mikhaylenko. 2016. *Orbital Battleship: A Guessing Game to Reinforce Atomic Structure*. *Journal of Chemical Education*. Vol. 93, No. 9. pp. 1595–1598.

Lage, M.J., G. J. Platt and M. Treglia, 2000. Inverting the Classroom: A Gateway to Creating an Inclusive Learning Environment. *Journal of Economic Education*. Vol. 31, No. 1. pp. 30–43.

Lopes, A. P., and F. Soares, 2017. *What Do Students of a Higher Education Institution Think About Flipped Learning*. EDULEARN17 Proceedings, 1 (July). pp. 2759–2766. https://doi.org/10.21125/edulearn.2017.1582

Maheshwari, P., and N. Seth. 2019. Effectiveness of flipped classrooms: A case of management education in central India. *International Journal of Educational Management*. Vol. 33, No. 5. pp. 860–885. https://doi.org/10.1108/IJEM-10–2017–0282

Mazur, E. 2009. Farewell, Lecture. *Science*. Vol. 323. pp. 50–51.

McLaughlin, J. E., M. T. Roth, D. M. Glatt, N. Gharkholonarehe, C. A. Davidson, L. M. Griffin, R. J. Mumper. 2014. The flipped classroom: A course redesign to foster learning and engagement in a health professions school. *Academic Medicine*. Vol. 89, No. 2. pp. 236–243. https://doi.org/10.1097/ACM.0000000000000086

Novak, G. M. and E. T. Patterson. 1998. Just-in-Time teaching: Active learner pedagogy with WWW. Retrieved from http://webphysics.iupui.edu/JITT/ccjitt.html.

Özüdoğru, M., and M. Aksu. 2020. Pre-service teachers' achievement and perceptions of the classroom environment in flipped learning and traditional instruction classes. *Australasian Journal of Educational Technology*. Vol. 36, No. 4. pp. 27–43. https://doi.org/10.14742/AJET.5115

Talbert, R. 2014, Toward a common definition of 'Flipped Learning'. Chronicle of Higher Education. https://www.chronicle.com/blognetwork/castingoutnines/toward-a-common-definition-of-flipped-learning

Vimala, A., and P. Muniandy. 2018. Effectiveness of Flipped Classroom on Students' Achievement and Attitudes towards English Language in Secondary School. *Journal of Innovative Technologies in Education*. Vol. 2. pp. 9–15. https://doi.org/10.1017/CBO9781107415324.004

Webb, M., E. Doman and K. Pusey. 2014. Flipping a chinese university efl course: What students and teachers think of the model. *Journal of Asia TEFL*. Vol. 11, No. 4. pp. 53–84.