Achievement In Organic Chemistry Through E-Module and Flipped Classroom Approach: An Experimental Study

Mahadeb Chattopadhyay[1] and Subhankar Ghosh[2]
[1]Associate Professor, Head and [2]Assistant Professor
[1]P. G. Department of Teacher Education (M.Ed.), Rajendra Academy for Teachers' Education, Affiliated to Baba Saheb Ambedkar Education University, Kolkata, West Bengal
[2]Department of Education, The University of Burdwan, Golapbag, Purba Bardhaman, West Bengal
[1]educhemchatterjee@gmail.com (Corresponding Author)

Abstract

Education is an important instrument to technological and socio-economic development of every nation. Technology integration with pedagogy can change the scenario of outcome-based education. This study measures the effectiveness of e-Module and Flipped Classroom approach on the organic chemistry achievement. The researcher used e-Module (Self Learning Material) based on Programme Instruction which was developed and validated by the researcher. The researcher also used e-Content videos for flipped classroom teaching which were prepared by the researcher and validated by the expert's opinion. The effectiveness of two instructional approaches on the achievement in organic chemistry among students was measured by conducting quasi-experimental study using achievement test at pre and post intervention stage. Researchers created two experimental and one control groups to conduct this research in experimental setting without full control of intervening and moderator variables. This study used 144 sample students having chemistry as their major elective subject in a Senior Secondary School (Burdwan Model School) affiliated to CBSE, in Purba Bardhaman District in West Bengal. Purposive and random sampling techniques were employed at the various stages. The data were collected and analysed by inferential statistics such as ANOVA, ANCOVA with Post-Hoc analysis and Pair sample t-test. The result showed that the achievement of XI-standard student in organic chemistry was better through E-Module than Conventional approach; similarly, the achievement of students was better for Flipped Classroom approach than Conventional approach. The results revealed that the Flipped classroom approach was the most effective instructional approach in organic chemistry learning for 11th standard students whereas e-module approach was also effective as self-instructional approach in parallel with flipped classroom instruction.

Keywords: e-Module, Flipped-Classroom, e-Content Video, Achievement, Organic-Chemistry, Quasi-Experimental

Introduction

In the digital age, different instructional approaches and modules are used in the classroom to provide maximum learning experiences among students. The role of teacher has changed from authoritarian to facilitator; autocratic to democratic in the classroom teaching by using modern teaching-learning methods and tools integrated with technology. In many research works, more emphasis is given over methods and techniques that may help the students to understand the concept instead of merely helping them to acquire knowledge. Learner centric teaching approaches depending

on the students' individual difference that needs different way of teaching process. The instructional approach, for example e-module approach is the self-instructional approach in this study. Technology in the 21st century allows instantaneous access to information through various technological tools such as computer, laptop and smart phone. NEP-2020 gives a direction towards the use of technology in an interactive way so that learning should be enjoyable and holistic. In this study, the technological integration with the traditional method is reflected in the flip classroom approach.

The entire education system is not only influenced by teacher, students and curriculum but also teaching-learning has a greater impact on whole education system by the progress of science and digital tools through numerous innovations. Traditional teaching-learning practices is less effective nowadays as it is totally converted to teacher centric autocratic system of teaching. In the traditional teaching-learning process, without use of technology, students were restricted to conventional materials like chalk, blackboard and text book etc. In this study, significant changes were introduced in the teaching-learning process, shifting from traditional to technology integrated blended learning which is further shifted to self-learning approach, that is e-Module. It will be better for future generation if teaching-learning process transform to learning-teaching process by the minimum help of teacher and maximum effort of learners.

Literature Review

Komalavalli and Amsayal (2022) conducted a study on the effectiveness of multimedia e-content module to enhance achievement in English among Grade 9 boys. Parallel group experimental design was employed. The pre-test and post-test were administered to both the experimental group and control group and data were collected. The result revealed that a significant difference between the experimental group and the control group exists. Findings stated that the use of multimedia e-Content teaching strategy has a significant impact on enhancing the achievement in English among the Grade 9 boys.

Sankar and Benjamin (2022) conducted research involving pre-test-post-test control group design on learning chemistry through flipped classroom approach at 10th standard level. It was found that flipped classroom instruction was effective in comparison to conventional method when 10th standard students learn chemistry. It was reported that the mean pre-test scores significantly differ from post-test achievement score in chemistry learning in experimental group through flipped classroom method among the 10th standard students.

Edgar (2021) focused on the utilisation of self-learning module in the academic achievement in Economics of students in public secondary schools. The study was descriptive and experimental in nature. It was found that the academic achievement level was satisfactory before using module and after the utilisation of module achievement level was very satisfactory and outstanding.

Gupta and Mishra (2020) conducted an experimental study with single group pre-test-post-test design on the effectiveness of developed e-Module in terms of achievement in educational administration course among M.Ed. trainees selected through purposive sampling. There was no control group and only one experimental group was use to carry out this research. The result revealed that achievement of M.Ed. trainees through e-module was

increased which reported the developed e-module was effective.

Yulando (2019) conducted a study on electronic module design and development: an interactive learning. The module was designed as a learning medium that can be used for teaching, mentoring, and learning tools. This module also supports materials such as animations, links, text, audio, images, videos, and quizzes to complete and assist the learning process. The findings revealed that according to response of media expert's product was in the excellent category and the data showed the feasibility test, obtaining a percentage of 93.4%.

Sujisha and Jesa (2018) carried out to measure the effectiveness of flipped classroom strategy on the achievement in organic chemistry among Grade 9 students by comparing the achievement scores after the treatment in experimental and control group. The statistical t-value was 4.042 which was higher than the critical point 2.58 for significant at 0.01 level. A significance difference of post-treatment mean score exist between experimental and control group. This showed that the treatment given to experimental group was effective for the achievement in organic chemistry.

Research Gap

The reviewed studies indicate that considerable research has been conducted on e-modules and student achievement in subjects such as English, Economics, and Mathematics. However, only limited research has examined the impact of e-modules on achievement in Organic Chemistry, and very few studies have been carried out in West Bengal focusing on Organic Chemistry achievement through e-modules. On the other hand, various research work done in India and abroad on the achievement through Flipped Classroom approach but not a good number of research work done by researchers by taking Flipped classroom approach and achievement in organic chemistry.

Researcher selects organic chemistry as instructional content because chemistry is related to our daily lives and researcher also select Grade 11 students in this study because the study of organic chemistry starts from Grade 11 in CBSE board. So, the researcher focuses on the achievement in organic chemistry in terms of two instructional approaches i.e. e-module and flipped classroom approaches among Grade 11 students.

Hence, the researcher has been taken instructional approach as independent variable and achievement taken as dependent variables.

Research Objectives

1. To study the achievement in organic chemistry through e-Module and Flipped classroom approach.

2. To assess the pre-test achievement score of XI standard students in organic chemistry taught through e-Module, Flipped classroom and conventional approach.

3. To assess the post-post achievement score of XI standard students in organic chemistry taught through e-Module, Flipped classroom and conventional approach.

4. To study the effectiveness of instructional approach in terms of achievement in organic chemistry.

Hypotheses

H_o1. There would be no significant mean difference of pre-test achievement score between e-Module, Flipped Classroom and conventional groups.

H_o2. There would be no significant mean difference of post-test achievement

score between e-Module, Flipped Classroom and conventional groups.

Definition of Important Terms

- Achievement: Achievement is the learning outcome of students after the completion of the educational units or element.

- e-Module: It is a course material which provides the content in a logical and sequential manner that helps the students studying from their home or wherever and whenever by using smart phone, tablet, computer or laptop (Yulando, Sutopo and Franklin, 2019).

- Flipped Classroom: It is an instructional environment where normal classes are inverted and short duration of teaching videos are watches by the students at their home before class (Sujisha and Jesa, 2018). In-class time teachers do exercises and discussions with the same students and same content.

Methodology

This study was experimental in nature. Few extraneous variables e.g. classroom environment, teacher, curriculum content, medium of instruction were controlled in the experimental setting. But all types of moderators and intervening variable were not controlled to conduct the true experiment so researcher adopted quasi-experimental design. Full controls of moderator and intervening variables have not been done by the researcher during this experiment. In this study one dependent and one independent variable was involved. This study was confined to the content of XI standard Organic Chemistry topics of CBSE Curriculum and conducted in only one CBSE school. This study was carried out with a sample of 144 XI standard students those who are came from CBSE board and passed 10th Class board exam under CBSE board. Total sample students were divided in three groups e.g. Control group, experimental group1 and experimental group2. Two types of tools e.g. teaching tools and assessment tool were used to study the effectiveness. Quantitative data analysis techniques were applied to analyse and interpret the data.

Variables

Dependent: Achievement in Organic Chemistry

Independent: Instructional Approaches (Conventional, e-Module and Flipped Classroom)

Population and Sample

The population of the study was Grade 11 students of CBSE school in Purba Bardhaman district. This study was conducted only in one CBSE school which was the sample school i.e. Burdwan Model School, near Burdwan town of district Purba Bardhaman in West Bengal chosen purposively. Out of 248 students of science background from different section only 156 students of Grade 11 with science background having Chemistry as their major subject were selected randomly as sample. But finally, 144 students from three groups completed this experimental procedure and gave their responses for the analysis and interpretation of data. The formation of three groups before treatment was done which is given in Table1. These three groups were formed to study the achievement of Grade 11 students in organic chemistry through different instructional approaches. This sample was divided in three groups i.e. two experimental groups and one control group to study the effectiveness of e-module and flipped classroom approach in organic chemistry learning.

Control group was the reference group and two experimental groups were marked as experimental group1 where e-Module treatment was given and experimental group2 where Flipped classroom approach was adopted.

Table1: Distribution of sample in three groups

Instructional Approaches	1st Experimental Group (e-Module)	2nd Experimental Group (Flipped Classroom)	Control Group (Conventional)
Number of Students	48	48	48

Table 1 represents the sample distribution in the control group (Conventional method) and two experimental groups (e-Module group and Flipped classroom group) equally. Total forty-eight (48) students selected for the control group and forty-eight (48) students selected for each experimental group.

Statistical Technique and Software used

Statistical techniques used were: Descriptive statistics (Mean, Standard Deviation) and Inferential Statistics (Pair sample t-test, ANOVA and ANCOVA).

Software used were: MS Excel-2010 and SPSS-21

Tools used

- Teaching Tools
    - i. Self-developed "e- Module" on selected Organic Chemistry Topics of Grade 11 was constructed and standardised.
    - ii. Self-prepared "Teaching Videos" for Flipped Classroom approach were constructed and standardised.
- Assessment Tools:
    - i. Assessment tools used in this study were two tests e.g. "Pre-Achievement Test in Organic Chemistry" and "Post-Achievement Test in Organic Chemistry" for Grade 11 students as per CBSE curriculum and standardised by the researchers.

Analysis and Interpretation

H_O1. There would be no significant mean difference of pre-test achievement score between e-Module, Flipped Classroom and conventional groups.

Descriptive statistics

Table 2: Group Statistics of Pre-test Achievement in EG-1, EG-2 and CG

Groups / Descriptive Statistics	1st Experimental Group (EG-1) (e-Module)	2nd Experimental Group (EG-2) (Flipped Classroom)	Control Group (CG) (Conventional Approach)
N	48	48	48
Mean	13.75	13.27	13.58
SD	2.392	2.229	2.872
SE	0.345	0.322	0.415

Note: N indicates total frequency/sample; SD indicates Standard Deviation; SE indicates Standard Error.

Table2 depicts that the mean and SD of pre-test score of 48 students in e-Module group are 13.75 and 2.392 respectively. Similarly, the mean and SD of pre-test score of 48 students in flipped classroom group are 13.27 and 2.229 respectively. Whereas, mean and SD of pre-test score of 48 students in conventional group are 13.58 and 2.872 respectively. The mean pre-test score in three groups e.g. EG-1, EG-2 and CG are nearly equal. So, ANOVA statistics was employed to know the actual group difference and to interpret whether the difference is significant or not.

Inferential statistics

Table 3: One way ANOVA for Pre-test score in three groups

Source of variation	Sum of Squares	df	Mean Square	F-critical	F-value	Sig. (2-tailed)
Between Groups	5.681	2	2.840	3.06	0.450#	0.639
Within Groups	890.146	141	6.313	-	-	
Total	895.826	143	-	-	-	

Note: # indicates the value associated is insignificant

It is observed in Table 3 that the F value 0.450 (p> 0.05) which is higher than critical F-value at 0.05 level. So, Null hypothesis (H_O1) stated "There would be no significant mean difference of pre-test achievement score between e-Module, Flipped Classroom and Conventional groups" is not rejected. Hence, it is confirmed that no significant mean difference exists between three instructional groups e.g. EG-1, EG-2 and CG. This indicated the homogeneity of three groups before intervention.

H_O2. There would be no significant mean difference of post-test achievement score between e-Module, Flipped Classroom and conventional groups.

Table 4: Group statistics of Pre-test and Post-test scores in EG-1, EG-2 and CG

Groups Descriptive Statistics N=48		EG-1 (e-Module Group)	EG-2 (Flipped Classroom Group)	CG (Conventional Group)
		N=48	N=48	
Pre-test	Mean	13.75	13.27	13.58
	SD	2.392	2.229	2.872
Post-test	Mean	31.75	32.79	21.33
	SD	6.522	7.047	5.829

Note: N indicates total frequency/sample; SD indicates Standard Deviation; EG-1 indicates 1st Experimental Group; EG-2 indicates 2nd Experimental Group; CG indicates Control Group.

Table 4 depicts that the mean and SD of pre-test score among 48 students in e-Module group are 13.75 and 2.392 respectively whereas mean and SD of post-test score are 31.75 and 6.522 respectively. Similarly, the mean and SD of pre-test score among 48 students in flipped classroom group are 13.27 and 2.229 respectively but mean and SD of post-test score are 32.79 and 7.047 respectively. In case of conventional group, mean and SD of pre-test score

among 48 students are 13.58 and 2.872 respectively but mean and SD of post-test score are 21.33 and 5.829 respectively. The mean score in three groups is nearly equal in case of pre-test but not equal for post-test shown in Figure1. So, ANCOVA statistics was employed to post-test between three groups to know whether the difference in post-test achievement score among three groups is significant or not.
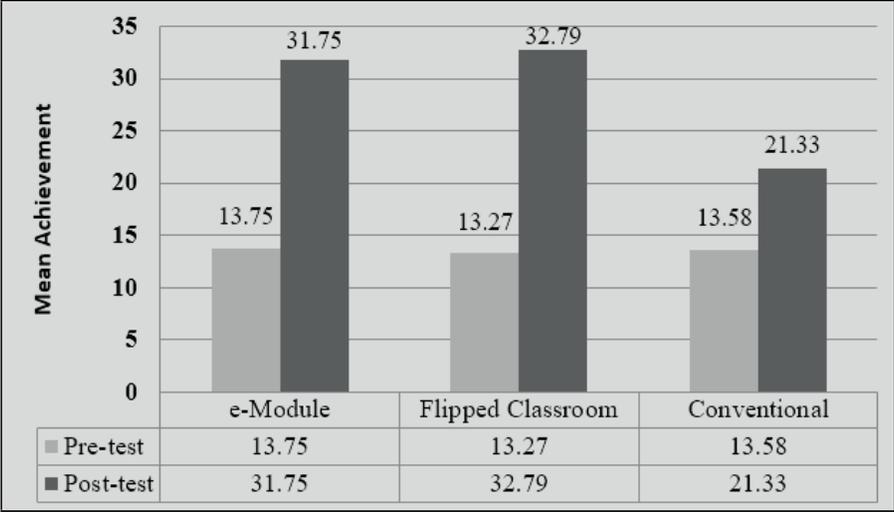

Fig 1: Column graph showing mean value of Pre-test and Post-test Achievement in e-Module, Flipped Classroom and Conventional groups

Inferential statistics

Table 5: ANCOVA for Post-test score showing Interaction effect

Source	Sum of Squares	df	Mean Square	F-Value	Sig. (p)
Pre-test achievement	1427.785	1	1427.785	44.814	0.000*
Instructional Approaches	479.429	2	239.714	7.524	0.000*
Pre-test X Instructional Approach	51.392	2	25.696	0.807	0.449
Error	4396.676	138	31.860	-	-
Total	127776.00	144			

Note: df is the Degree of Freedom

It is reported from the result given in Table5 that the interaction between pre-test score and instructional approach is not significant as the F-value for this interaction term is 0.807 (P>0.05). This indicates that covariate (pre-test score) has no influence on the dependent variable (instructional approach). It

is also observed in Table 5 that the F-value of post-test for instructional approaches is 7.524 (p< 0.05) which is higher than critical F-value at 0.05 level. So, Null hypothesis (H_O2) stated "There would be no significant mean difference of post-test achievement score between e-Module, Flipped Classroom and conventional groups" is rejected. So, there exists significant mean difference of post-test achievement in Organic chemistry among Grade 11 students in three instructional groups. So, post-Hoc analysis was carried out to know actual difference between groups.

POST-HOC Analysis

Table 6: Post-Hoc Analysis (Bonferroni Method) Showing Mean Difference between Groups with Adjusted Mean Post-test score

Instructional Approach(A)	Instructional Approach(B)	Adjusted mean post-test achievement score	Mean Difference (A)-(B)	SE	Sig. (p)[a]
EG-1 (e-Module) 31.395[a]	EG-2	33.071[a]	1.676	0.821	0.454
	CG	21.276[a]	10.119	0.815	0.000*
EG-2 (Flipped Classroom) 33.071[a]	EG-1	31.395[a]	1.676	0.818	0.454
	CG	21.276[a]	11.795	0.815	0.000*
CG (Conventional) 21.276[a]	EG-1	31.395[a]	10.119	0.818	0.000*
	EG-2	33.071[a]	11.795	0.821	0.000*

Note: a. p values are adjusted using the Bonferroni method. SE indicates Standard Error of mean; p indicates the Probability. EG-1 indicates 1st Experimental Group; EG-2 indicates 2nd Experimental Group; CG indicates Control Group.

Table 6 depicts the post-Hoc analysis of post-test score in three groups e.g. e-Module Group, Flipped classroom group and Conventional Group. The actual mean post test score in EG-1, EG-2 and CG are 31.75, 32.79 and 21.33 respectively reflected in Table 4. In contrast to actual mean post-test score, it is observed from Table 6 that the adjusted mean post-test score of EG-1, EG-2 and CG are 31.395, 33.071 and 21.276 respectively. The mean difference of Post-test achievement scores between e-Module and Conventional groups is 10.119 (p<0.05) which is significant; between Flipped Classroom and Conventional groups the mean difference is 11.795 (p<0.05) which is significant. But in comparison between e-Module and Flipped classroom group the mean difference is 1.676 (p>0.05) which is insignificant. So, the actual difference in post-test achievement score is observed between EG-1 and CG; between EG-2 and CG. The difference is due to the low score in post-test achievement in CG (Conventional Group).

Pair-sample t-Test

Table 7: Pair sample t-Test showing actual mean Difference within Groups

Groups		N	Mean	SD	t-Value	df	Critical t-Value	Sig. (p)
e-Module	Pre-test	48	13.75	2.392	20.359	47	2.01	0.00*
	Post-test	48	31.75	6.522				
Flipped classroom	Pre-test	48	13.27	2.229	22.998	47	2.01	0.00*
	Post-test	48	32.79	7.047				
Conventional	Pre-test	48	13.58	2.872	13.717	47	2.01	0.00*
	Post-test	48	21.33	5.829				

Note: N indicates total frequency/sample; SD indicates Standard Deviation.

Table7 depicts the results of pair sample t-test of post-test achievement score in three groups. Analysis showed in Table7 that the t value is 20.359 (p<0.05) due to e-Module instruction; t value is 22.998 (p<0.05) due to flipped classroom instructional approach and t value is 5.829 (p<0.05) due to conventional approach. The t-value between pre-test and post-test due to different instructional approach is significant but the high value of t indicates the high difference between pre-test and post-test score indicates the high effectiveness if instruction. The t-value is higher in case of flipped classroom approach and low in case of conventional approach.

Major Findings

ANOVA result showed that mean difference in pre-test score (F=0.450, p=0.639) between EG-1, EG-2 and CG is not significant among XI standard students. This indicates the homogeneity of three groups before the intervention applied.

The results of post-Hoc analysis also showed that the difference of adjusted post-test mean after intervention between e-Module and Flipped Classroom groups is 1.676 (p>0.05) which is not significant among XI-standard students.

The result of post-Hoc analysis also showed that the difference in the adjusted mean scores after intervention between e-Module and Conventional approach is 10.119 (p<0.05); and between Flipped Classroom approach & Conventional approach is 11.795 (p<0.05) and both are significant.

The pair sample t-Test analysis indicates that the actual mean difference between pre-test and post-test achievement in all the three groups e.g. e-Module, flipped classroom and conventional groups are significant.

Discussion

It is found from the analysis of data that before the treatment given to separate groups, the mean and SD score in experimental group1, experimental group2 and control group are nearly equal. So, to check the equality of three groups before treatment was given, ANOVA was applied to check the homogeneity. It was found that before treatment the result of ANOVA reported the higher statistical F value (p> 0.05) than critical F-value at 0.05 level. Three

groups were equalising in terms of pre-test achievement score.

The results showed that after treatment given mean and SD of post-test score in 1st experimental group (E-Module) and 2nd experimental group (flipped classroom) are comparatively equal but control group (conventional approach) has lower values of mean and SD. The mean score before interventions in three groups are nearly equal but mean score after interventions are not comparatively equal in three groups shown in Figure 1. So, ANCOVA statistics reported that there was no interaction effect of co-variate (pre-test score) with instructional approaches on the post-test achievement score in organic chemistry and post-Hoc analysis was carried out to know whether between group difference is significant or not. Results of post-Hoc analysis showed adjusted mean difference of post-test score is minimum between e-Module and Flipped classroom approach which indicates their comparatively equal effectiveness; but adjusted mean difference is maximum not only in case of e-module and conventional approach but also for flipped classroom and conventional approach which indicates the less effectiveness of conventional approach in compare to e-module and flipped classroom approach.

It was also reported in the pair-sample t-test analysis table that the mean difference between pre-test score and post test score was minimum for conventional approach signify it's less effectiveness in chemistry learning in control group whereas the mean difference between pre-test and post-test score was maximum in case of experimental group-2 e.g. flipped classroom approach which signify the most effective instructional approach. Similarly, the mean different between pre-test and post test score in experimental group-1 e.g. e-module was the comparatively equal but slightly lower than the conventional approach. The analysis of data by ANCOVA with post-Hoc analysis and Pair sample t-test confirm the most effective instructional approach is flipped classroom approach and e-module is also effective as self-instructional approach in comparison to conventional approach.

Educational Implication

In the contemporary educational practices, the very important factor for learning is the application of instructional technology in the classroom. All school teachers now-a-days use technology in classroom but there was lack of technology integration with pedagogy. So, teachers should emphasise on the quality education in schools by selecting proper instructional technology through the integration of technology with pedagogy. The researcher conducted this study not to just compare two instructional approaches: e-module and flipped classroom approach in comparison to conventional approach but rather to understand the organic chemistry achievement in terms of different instructional approaches and to find out the best instructional approach to enhance achievement and study their effectiveness. Present practices of classroom teaching in many senior secondary schools focuses only on the acquisition and dissemination of knowledge not to focus on the individual learners towards self-learning.

The way of teaching of science especially organic chemistry teaching is rapidly changing the technological landscape in modern educational scenario. So, the science teachers have an important role to challenge their way of teaching for the betterment of learning in this changing scenario. Everyone knows that the development of science teaching depends on the various factors such as instructional approaches, curriculum content, pedagogical framework etc.

The most important factor highlighted in this study is the variation of achievement with changing the instructional approaches. e-Module instruction was given to students for the better understand of 3-D structure of organic chemistry by self-learning. Flipped classroom approach is the blended approach which helps the students to connect their previous learning with present complex matter. The result of the study revealed that e-module and flipped classroom would be helpful for the students in developing their conceptual understanding in organic chemistry and students will learn easily. So, school teachers irrespective of their subjects should try to integrate technology with pedagogy to develop instructional model like e-module and adopted flipped classroom approach for holistic learning and outcome-based learning.

Conclusion

The results of the study reported that three groups were equalising through pre-test achievement score. There was significant difference of mean achievement scores between pre-test and post-test stage (t=20.359, p<0.05) among students in organic chemistry due to e-Module Instruction; and due to Flipped Classroom approach the difference between pre-test and post-test score (t=22.998, p<0.05) is significant; and due to conventional approach the difference between pre-test and post-test score (t=13.717, t<0.05) is also significant. The improvement in achievement is low due to conventional approach. In term of adjusted mean difference, actual mean post-test difference is observed between e-Module and conventional group; and between flipped classroom and conventional group. The effectiveness of flipped classroom and e-Module approach is better that conventional approach; but flipped classroom approach is slightly better than e-Module approach.

So, it is clearly concluded that a self-learning material like e-Module will very helpful for student's learning independently. Good quality instructional materials make teaching-learning process more interactive. Flipped classroom approach is the blended method by which the achievement in organic chemistry is higher. So, the teaching learning process integrating with technology can changes the scenario of instructional approach from teacher centric to learner centric. If the learner required multi-sensory learning materials by which they can acquire the knowledge, better understand the concept by the adaptation of interactive instructional approaches, the learning will be more fruitful and holistic.

References

Adhikary, C. (2018). *Development of some improvised and sustainable teaching–learning modules in chemistry and to study their pedagogical effectiveness.* (Doctoral thesis, Department of Education, The University of Burdwan, Purba Burdwan).

Akinyemi, A., et al. (2018). Comparative effects of an individualised computer-based instruction and a modified conventional strategy on students' academic achievement in organic chemistry. *The Journal of Positive Psychology and Counselling*, 1–19. https://www.researchgate.net/publication/326903027

Alkhutaba, A. Y. (2013). *The attitude of chemistry teachers towards using the computer in teaching eleventh grade.* (Doctoral thesis, Department of Education, Aligarh Muslim University, Aligarh).

Alsalhi, N., Eltahir, M., & Al-Qatawneh, S. (2019). The effect of blended learning on the achievement of ninth-grade students in science and their attitudes towards its use. *Heliyon*, Article e02424. https://doi.org/10.1016/j.heliyon.2019.e02424

Alsalhi, N. R., et al. (2021). The effect of blended learning on achievement in physics: A case study at Ajman University. *The Electronic Journal of e-Learning*, 19(1), 1–17. https://www.researchgate.net/publication/349368367

Anggiyani, N., Arum, A., & Niwat, S. (2021). Blended learning in chemistry: A systematic review from 2010 to 2019. *Journal of Education Khon Kaen University*, 44(2), 19–40.

Behrens, N. J. (2007). *Investigation of interactive teaching techniques to promote student understanding in chemistry*. (Doctoral dissertation, Iowa State University). https://lib.dr.iastate.edu/rtd/14654

Benjamin, A., et al. (2016). Effect of problem-based learning on students' achievement in chemistry. Journal of Education and Practice, 7(33), 103–108. https://www.iiste.org

Birundha, S. (2020). Effectiveness of flipped classroom in teaching organic chemistry at standard XI. *Shanlax: International Journal of Education*, 9(1), 198–204. https://doi.org/10.34293/education.v9i1.3567

Chaudhary, P. (2002). *A comparative study of the effectiveness of gaming and mastery learning models on students' self-concept and achievement in chemistry*. (Doctoral thesis, Department of Education, Maharshi Dayanand University, Rohtak).

Chawla, J., & Singh, G. (2013). Construction and standardization of an achievement test in chemistry. *Malwa Journal of Education*, 4(4), 54–60.

Cole, C. (2020). Blended learning's impact on student performance and engagement in a middle school language arts classroom (Master's thesis, Northwestern College, Iowa). https://nwcommons.nwciowa.edu/educationmasters

Cormier, C., & Voisard, B. (2018). Flipped classroom in organic chemistry has significant effects on students' grades. *Frontiers in ICT*, 4, Article 30.

Edgar, et al. (2021). Utilization of self-learning modules in the new normal and academic achievement in economics of students in public secondary schools. *International Journal of Computer Engineering in Research Trends*, 8(5), 85–94.

Eunice, O., & Mishack, G. (2017). Effects of self-regulated learning training on students' metacognition and achievement in chemistry. *International Journal of Innovation in Science and Mathematics Education*, 25(2), 34–48.

Gayathri, & Vijayarani, K. (2019). Effectiveness of flipped classroom strategies on enhancing learning performance in chemistry among XI standard students. *International Journal of Research and Analytical Reviews*, 6(1), 597–601.

Ghafoor, Z. A. (2019). *Flipped learning: A learner-centred approach to teaching English at the tertiary level.* (Doctoral thesis, Queen Mary's College, Chennai).

Gupta, A., & Mishra, R. (2020). Effectiveness of a developed electronic module on achievement in educational administration of M.Ed. students. *EasyChair Preprints*, No. 2377.

Halasa, S., et al. (2020). Comparing student achievement in conventional learning with a combination of blended and flipped learning. *Nursing Open*. https://doi.org/10.1002/nop2.492

Hanson, R. (2017). Enhancing students' performance in organic chemistry through context-based learning and micro-activities: A case study. *European Journal of Research and Reflection in Educational Sciences*, 5(6), 7–20.

Joshua, O., & Amina, C. (2021). Effects of computer-aided concept-diagram and VEE-mapping strategies on organic chemistry learning outcomes among senior secondary school

students in Niger State, Nigeria. *IOSR Journal of Research & Method in Education*, 11(4), 15–21. https://doi.org/10.9790/7388-1104051521

Komalavalli, S., & Amsayal, C. (2022). Effectiveness of multimedia e-content modules in enhancing achievement in English among standard IX boys. *Journal of Positive School Psychology*, 6(6), 25–31. http://journalppw.com

Malliga, T. (2003). *Relative effectiveness of computer-mediated multimedia presentation strategies in teaching chemistry at the higher secondary stage.* (Doctoral thesis, Bharathiar University, Coimbatore).

Mohd Hamid, S. N., et al. (2021). E-content module for chemistry MOOC: Development and students' perceptions. *Journal of Technology and Science Education*, 11(1), 67–92. https://doi.org/10.3926/jotse.1074

Okey, O., & Doris, O. (2018). Effects of instructional models on students' performance in organic chemistry in Obio/Akpor LGA, Rivers State. *International Journal of Education and Evaluation*, 4(6), 86–93.

Prabakaran, B., & Saravanakumar, A. R. (2021). Effectiveness of e-content modules in learning set language among ninth standard students. *Turkish Journal of Computer and Mathematics Education*, 12(2), 2515–2522.

Sankar, E., & Benjamin, A. E. W. (2022). Role of self-learning modules in chemistry at the secondary level. *International Journal of Creative Research Thoughts*, 10(6), d238–d243.

Siddiqui, U. (2013). *A comparative study of the effects of traditional teaching and computer-assisted instruction on secondary school students' attitude and achievement in physical science.* (Doctoral thesis, Aligarh Muslim University).

Sujisha, E. P., & Jesa, M. (2018). Effectiveness of flipped classroom strategy on achievement in organic chemistry among standard IX students.

Thosar, M. (2018). *Effectiveness of a programme based on self-regulated learning model for primary-level mathematics.* (Doctoral thesis, S. N. D. T. Women's University, Mumbai).

Yulando, S., Sutopo, & Franklin, T. (2019). Electronic module design and development: An interactive learning approach. *American Journal of Educational Research*, 7(10), 694–698. https://doi.org/10.12691/education-7-10-4