Innovative Teaching Strategies in Biology: Assessing Flipped Mastery vs. Flipped Classroom Learning

ABSTRACT

The current study examined the efficacy of Flipped Mastery Approach (FMA) and Flipped Classroom Learning (FCL) in helping 11th grade students grasp biology subjects based on differences in their previous knowledge levels. The study included a sample of 120 class 11 learners from the Indian state of Jharkhand, including 60 students in each of the experimental and control groups. In terms of the post-achievement score, the experimental group (FMA) fared better than the control group (FCL). The FMA approach was proven to be successful in helping low-achievers retain complex biological concepts over the long term.The ANOVA findings also showed that the type of teaching used to transfer the information impacts performance in a given topic, with FMA yielding better scores than FCL. This was ascribed to FMA's make available for students to see instructional films and complete topic-related activities many times until they attained 80% mastery of the material. Additionally, the students' prior knowledge concerning a given subject had an effect on their total performance. Students with greater prior knowledge levels were shown to have higher post-achievement scores in this study.Additionally, the study discovered that students in the FMA and FCL groups with varied degrees of prior knowledge scored substantially differently, with FMA consistently outperforming FCL across the board. These findings illustrate how FMA might aid students with lower previous knowledge levels in comprehending and remembering topics over time, as well as the significance of taking individual differences in achievement levels into account when evaluating instructional interventions.

Keywords:-

Flipped Mastery Approach, Flipped Classroom Learning, Previous knowledge level, Retention capacity

Introduction

Since education is a continuous process, it occasionally needs to be updated to meet the shiftingdemands of society in order to advance. A nation can address these demands by implementing novel and revolutionary modifications to the classroom teaching approach, which will encourage students' creativity and critical thinking.This involves introducing new ideas, processes, and tactics while encouraging inquiry, problem-solving, and discovery. According to (Skovsgaard, 2018), schools in the 21st century must prepare students for a rapidly changing world economically, socially, and technologically.Technology-integrated education, which provides limitless resources, is one of the preferred approaches to education. The flipped classroom learning (FCL), a novel approach that is student-oriented, self-paced and technology integrated. Developed by Bergman and Aaron (Bergmann & Sams, 2012) for students who cannot attend school

regularly, flipped learning has gained traction as a successful teaching method and trend in the past decade (Ceker, Eser, Fezile Ozdamli, 2016). The primary goal of flipped learning is to increase the amount of time teachers and students spend together in the classroom, whereas most conventional classroom instructors used it for lectures. However, according to Sams and Bergmann (2013), instructors should use the upper level of Bloom's Taxonomy for face-to-face instruction, while the lower level should be used outside of the classroom. Teachers appear to have several responsibilities. After reading the relevant literature, the researcher believes that flipped learning is a fantastic method for enhancing achievement, interest, motivation, and attitude towards the subject. Most studies were conducted with undergraduate students.(Matawali etal,2019;Alsalhi et al., 2021;Dİnçer & Polat, 2022;Förster et al., 2022). Many investigators have experimented with this technique with higher-secondary students in the fields of computer science, physics, and chemistry. (Preethi, 2019; Gayatri, 2019;Latha, 2020). Several research studies have shown that this method is advantageous for acquiring biological knowledge in middle and high schools, as well as for B.Ed. students. (Adams et al., 2016; Nair and Bindu, 2016;Malto et al., 2018;Bishop and Verleger, 2013). Parallel strategies such as blended and inverted learning have been found to be beneficial in the field of higher secondary biology education. (González-Gómez et al., 2016;Nair and R.L, 2016;Matawali et al., 2019). Bergman and Aron, the creators of flipped learning, discovered that when they combined this approach with mastery learning, chemistry students learned more effectively than the normal flipped learning.

Literature Review:

According to the analysis of Parikh, the nature of the subject, the way teachers teach, unfavorable sentiments and attitudes towards the subject because of a lack of concept clearances, a lack of resources, interest, and insufficient information about the topic's value in career development are the main causes of learning difficulties in biology classes (Parikh, 2024).The teaching methods used in higher secondary classes may not adequately capture students' attention or foster genuine curiosity about biological concepts. Additionally, the pressure of exams and rote memorization often associated with biology courses can discourage students from developing genuine passion for the subject. The issue of disengagement in biology at the higher secondary level is multifaceted, with various studies highlighting the different contributing factors and potential strategies to address this problem.Using a variety of teaching techniques and tactics that accommodate diverse learning styles helps increase students' interest in a subject and their involvement in the learning process. According to their preferred learning styles, students that actively engage in the educational process can attain highin the learning process. (Madhuri, 2024).Results of the study conducted by Bong in South Korean high schools, showed that cognitive engagement and disengagement were predicted by the exogenous factors such as perceived autonomy support, perceived teacher control, and technological self-efficacy (Bong et al, 2023). Innovative teaching methods for student involvement are highlighted in the research, by Diem , among pre service biology teachers in Vietnam, which emphasizes obstacles in integrating theoretical knowledge with classroom practice. In order to better prepare pre-service teachers for their professional path, the program places a strong emphasis on experiential learning through teaching apprenticeships, reform and other areas (Diem et al.,2024).In conclusion, a number of issues, such as curriculum deficiencies, teacher effectiveness, their

practices, and difficulties with online learning platforms, can be blamed for the low level of interest in biology among students of various levels across the world . To solve these problems, a thorough strategy that addresses curriculum reform and other topics is needed.Addressing student disengagement in K-12 biology education requires a multifaceted approach that considers curriculum design, pedagogical strategies, and the learning environment, with particular attention to the unique challenges and opportunities presented by online learning platforms. Rahman found a positive correlation between co- curricular activities and achievement in a particular subject through machine learning. (Rahman et al., 2021).

In 2012, Bergman and Aaron devised flipped learning, a revolutionary teaching approach, to assist students who are unable to attend classes on a regular basis.This approach's key characteristic is that, through the use of technology, the content is sent to students' homes or outside of the classroom in the form of instructional videos or written materials, while class time is allocated solely to activities, discussions, presentations, and demonstrations where students actively learn and teachers serve as facilitators. Zainal and Said (2017).This student-centered teaching approach is very adaptable, highly individualised, and has proven successful across a variety of subject areas and educational levels.This method's efficacy has been demonstrated in a number of fields, such as nursing (Cho & Kim, 2019) and dance (Lin et al., 2019), demonstrating its flexibility.Flipped learning has been beneficial on a variety of factors, including interest, academic anxiety, student involvement, retention of concepts, attitude towards many subjects, including biology, and these results have been favourable(Liji, 2019)(Gayatri, 2019).Numerous studies have demonstrated its efficacy in achieving success in a variety of areas, including science, math, English, chemistry, physics, and computer science (Bhagat, 2016; Hajari, 2016; McCollum, 2017).

Although several studies have demonstrated its efficacy in improving student performance, satisfaction, and attitude, creating a lesson plan that incorporates learning resources and activities as well as creating quizzes for feedback present difficulties. Despite the numerous research that highlight the benefits of flipped learning, some have shown that this approach has drawbacks as well. According to Mellefont and Fei, the efficacy of the flipped classroom may be hampered by students' lack of preparation(Mellefont, L. A., & Fei, 2016). When watching the video, students were easily distracted(Toto, R., & Nguyen, 2009). Furthermore, students' self-motivation was crucial to the flipped classroom's success.(Wang, 2017) Additionally, teachers find it challenging to keep an eye on their students' knowledge and provide them immediate feedback (Milman, 2012). In this regard, the researcher investigated the efficacy of flipped mastery learning, which was created by Bergman and Aron and offers a more self-paced, learner-centred, and inclusive approach that has been shown to be successful in teaching chemistry.They rebuilt flipped learning by including the mastery learning technique, which proved to be successful in teaching chemistry. Given that biology is a discipline with a large curriculum and complex terminology, this approach has the potential to completely transform how biology is taught and learnt in traditional classroom settings. Examining its efficacy in this situation is urgently needed. Additionally, mastery learning has been shown to be a successful strategy for raising students' performance in a variety of courses, particularly for weaker students (Kulik et al., 1990).Bala (2020) discovered that mastery learning was beneficial in improving the performance andattitude of fifth-grade children who had difficulty understanding mathematical concepts. It was discovered that the Mastery Learning Approach was more successful in raising students' scientific attitudes.(Patel,2021)

.

The most alluring aspect of this innovative approach is that it permits students study the material at their own speed and interest. It enables pupils to grasp one idea before going on to the next (Bergmann&Aron,2012).The flipped mastery technique may accommodate each student's needs to expand their understanding of the subject. Above all, this approach has the potential to strengthen students' 21st century abilities, including critical and creative thinking, teamwork, and problem-solving, all of which are crucial for biology learning. However, in order to achieve the intended learning objectives, creating a good lesson plan for this technique requires the teacher's creativity as well as thorough planning and preparation of the subject matter and related activities.By examining the efficacy of the flipped Mastery Approach in eleventh-grade biology and evaluating whether it was more successful than flipped classroom learning in transferring content, the researcher discovered a gap in this field. This study aimed to determine the effectiveness of flipped learning and flipped mastery learning approaches in biology achievement among eleventh-grade students.

The research questions were as follows.

1. How does the implementation of Flipped Mastery approach impact biology achievement among eleventh-grade students?
2. Which method is better in the transaction of learning content in 11^{th} grade biology – Flipped Classroom Learning (FCL) or FlippedMastery Approach(FMA)?
3. To what extent does Flipped Mastery Approach enhance content retention in biology learning for eleventh-grade students?
4. Does the interaction of teaching methods (FMA and FCL) and student's previous knowledge levels significantly affect their achievement in biology, as measured by post-test scores?

Materials and methods

Methodology serves as a framework for conducting scientific research. This constitutes the researcher's plan to conduct the study. It delineates the methods and procedures used to conduct the study, including sample selection, data collection, and analysis. It is a systematic approach by which scientists plan their investigation to enable them to use the chosen research tools to accomplish their objectives. It encompasses all critical aspects of research, including the overarching framework for the study as well as the methodologies employed for data collection, analysis, and research design (Khanday & Khanam, 2023). A quasi-experimental design was employed in the present study.A well-designed study should encompass a precise and well-defined research question, methodology for data collection, andtechnique for analysis and interpretation of the findings. All of these aspects were addressed through a carefully considered study design. The researcher selected anexperimental - control group, Post-Test design for the current investigation.

Variables of the study

A. Independent variable
   - Flipped Mastery Approach
   - Flipped Classroom Learning

B. Dependent Variable
   - Achievement in Biology

C. Intervening Variable

- Previous knowledge Level
  The intervening variable was controlled by administering a pre – test based on the 10^{th} class syllabus on photosynthesis and respiration in the plants. Based onthe pre-test scores, students in each group were divided into three subgroups: - low,average and high level (Stream, Mountain and Sky respectively).

SAMPLE

A sample of 120 standard XI Biology students was selected from two schools, Mar Gregorios Memorial Higher Secondary School and Holy Cross School in the district of Bokaro Steel City, Jharkhand State.The researcher used entire sections of the two schools' class 11 as a purposive sample.This procedure allocated the subjects into two groups: control and experimental. The experimental group was taught using the Flipped Mastery Approach, while the control group received instruction using the normal Flipped Classroom Learning method.Each group was further divided into three categories according to their previous knowledge level of the topic — low achievers (stream), medium achievers (mountain), and high achievers(sky) —based on the score of a pre-test administered to each group.

Table 3.1 Experimental Control Group Post-Test Design

Group	Treatment	Post-test
Experimental	Xe	O_1
Control	X_c	O_2

$X_e \rightarrow$ Experimental treatment given

$X_c \rightarrow$ Conventional treatment given

Comparison of O_1 and O_2 :- $O_1 - O_2$

FINDINGS OF THE STUDY

1. The pre-achievement score analysis given in table 1 shows that, Group 0 (experimental group taught by flipped mastery approach) maintains a higher mean of 56.5 and a median of 59.5, a standard deviation (SD) of 9.78 and a standard error (SE) of 1.263. Group 1(the control group taught by flipped classroom learning) exhibited a mean score of 54.8, a median of 54, with a lower SD of 6.45 and an SE of 0.832. These figures indicate that Group 0 outperformed Group 1 overall in the pre-assessment, but also demonstrates greater variability in performance. Therefore, these two groups (0 and 1) appeared to be comparable based on pre-test scores.

Table 1. Group Descriptives in Pre-Test Score

Group	N	Mean	Median	SD	SE
0 (Flipped Mastery Approach)	60	56.5	59.5	9.78	1.263
1 (Flipped Classroom Learning)	60	54.8	54	6.45	0.832

Table 2. Independent sample t- test for Pre- achievement score

t- score	df	p	Mean difference	SE difference
1.124	118	0.263	1.7	1.512

An independent sample t-test was used to compare both the groups on pre-achievement scores (table 2). The t-statistic was 1.124 with 118 degrees of freedom, resulting in a p-value of 0.263. The mean difference was 1.7 with an SE difference of 1.512. Similar to the previous comparisons, the p-value indicated no statistically significant difference between the groups' total achievement scores. The data presented in table 2 suggests that prior to the intervention or experiment, both groups exhibited relatively similar achievement levels.

In conclusion, the analysis of pre-achievement scores revealed no statistically significant differences between groups 0 and 1. While Group 0 demonstrated slightly higher mean and median scores, along with greater variability, the overall performance of both groups was comparable. The lack of significant differences in the total achievement scores, as evidenced by the p-value, suggests that the two groups entered the study with similar baseline knowledge and skills. This similarity in pre-intervention performance provides a solid foundation for assessing the impact of any subsequent interventions or experimental conditions, as any post-intervention differences can be more confidently attributed totreatment rather than pre-existing group disparities.

2. The present study concluded that the flipped mastery approach demonstrated significant benefits in improving student performancepost-achievement.Table 3 presents group descriptive statistics for the Flipped Mastery Approach (0) and Flipped Classroom Learning (1). It compares post-test achievement scores for each approach.

Table 3. Group descriptives of Post Test Score

Group	N	Mean	Median	SD	SE
0 (Flipped Mastery Approach)	60	70	70	4.87	0.628
1 (Flipped Classroom Learning)	60	64	64	6.8	0.878

When examining post-achievement scores, the Flipped Mastery Approach group had a mean of 70 and a median of 70, with an SD of 4.87 and an SE of 0.628. The Flipped Classroom Learning group had a mean of 64 and a median of 64, with a higher SD of 6.8 and an SE of 0.878. Overall, the Flipped Mastery Approach group demonstrated higher overall achievement than the Flipped Classroom Learning group. An independent sample t- test analysis revealed statistically significant differences between the groups. (Table 4)

Table 4. Independent sample t- test for Post - Achievement Score

t- score	df	p	Mean difference	SE difference
5.59	118	< .001	6.03	1.08

For the post achievement scores, the t-value was 5.59 with 118 degrees of freedom and a p-value of less than .001, indicating a statistically significant difference. The mean difference here was 6.03 with a standard error of 1.08. This finding suggests that the achievement scores between the two groups differed considerably, with a larger mean difference and higher standard error in favor of the Flipped Mastery Approach Group.

3. The flipped mastery approach seems to have yielded exciting results showing promise in bolstering students' long-term retention and understanding of academic material, as indicated by superior performance on delayed post-achievement tests. Yielding higher scores on thedelayed post - test means that, through this approach students not only get more of the content but also retain the learning for a longer time period. Tables 5 and 6 present the results of data analysis.

Table 5. Group descriptives of Delayed Post-Test Score

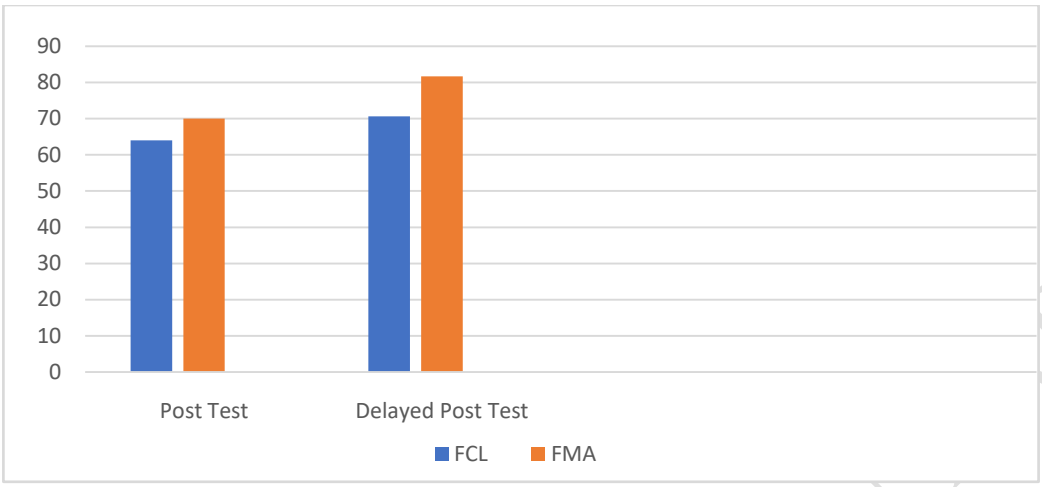
Group	N	Mean	Median	SD	SE
(0) Flipped Mastery Approach	60	81.7	81	5.96	0.77
(1) Flipped Classroom Learning	60	70.6	71	8.76	1.131

Table 6. Independent sample t- test for Delayed Post - Achievement Score

t- score	df	p	Mean difference	SE difference
8.09	118	< .001	11.07	1.369

Descriptive statistics of the performance of the two groups are presented in table 5 in terms of their delayed achievement scores between groups 0 (flipped mastery) and 1 (flipped classroom). Group 0 had a mean score of 81.7, a median of 81, an SD of 5.96, and an SE of 0.77. Meanwhile, Group 1 has a mean score of 70.6, median of 71, SD of 8.76, and SE of 1.131. This indicates a higher overall performance in delayed achievement for participants in the flipped mastery approach group compared to those in the flipped classroom learning group. The t-test statistic is 8.09 with 118 dfand a p-value of less than .001, demonstrating a significant difference between the two groups. The mean difference was 11.07 and SEwas 1.369. (Table 6) This remarkable mean difference indicates that the overall performance in delayed achievement scores was superior when using flipped mastery over flipped classroom learning.The graph below depicts the comparison of FCL and FMA in the post test and delayed post- test.

Graph 1. Comparison graph of achievement in post-test and delayed post-test



4. The study also revealed a significant interaction effect between teaching methods and students' previous knowledge levels on post-testbiology scores. The results of the two-way ANOVA statistical analysis are presented in table 7.

Table 7.Two-way ANOVA – With in group and between group effect on Achievement

	Sum of Squares	**df**	**Mean Square**	**F**	**p**
Individual effect of group of method of teaching (Group 0-FMA and Group 1- FCL)	785.4	1	785.4	77.56	< .001
Individual Effect of Category of previous knowledge level (0-low, 1-medium, 2-high)	2880.2	2	1440.1	142.21	< .001
Interaction effect of method of teaching and previous knowledge level on Achievement.	93.3	2	46.6	4.61	0.012

The table 7 displays the results of the Two-way ANOVA conducted on total post-achievement scores, examining the impact of two factors: group type (Flipped Mastery Approach - experiment vs. Flipped Classroom Learning - control) and previous knowledge level (low, medium, and high).

First, ANOVA showed a significant main effect of group type on total post-achievement scores, ($F = 77.56$, $p < .001$). This indicates that the type of instructional approach significantly influences the overall achievement outcome, with the flipped mastery approach (FMA-EXPT)yielding significantly higher scores than the flipped classroom learning (FCL-CONTROL) group.

Second, the analysis revealed a substantial main effect of the level of previous knowledge on total post-achievement scores, F (2, 114) = 142.21, p < .001. This suggests that participants' level of previous knowledge on the topic , categorized as low, medium and high, significantly impact ed their overall performance, with higher knowledge levels correlating with higher post-achievement scores.

Furthermore, the effect of the interactionbetween themethod of teaching and previous knowledgeon achievement also exhibited significance, F(2, 114) = 4.61, p = 0.012. This interaction effect suggests that the relationship between the method of teaching and the level of previous knowledge is not uniform across all levels, indicating a nuanced influence of the instructional approach on achievement outcomes depending on the participants' initial knowledge levels.

The result of analysis of post-hoc comparison for with in group interaction to determine the particular group that differs significantly is presented in the table given below.

Table 8. Post-hoc comparison of with in group interaction of method of teaching on post test score.

Group(0=FMA-EXPT, 1=FCL-CONTROL)	**Mean Difference**	**SE**	**df**	**t**	**P tukey**
0 ------- 1	6.27	0.712	114	8.81	< .001

Graph 2. Comparison graph w.r.t method of teaching

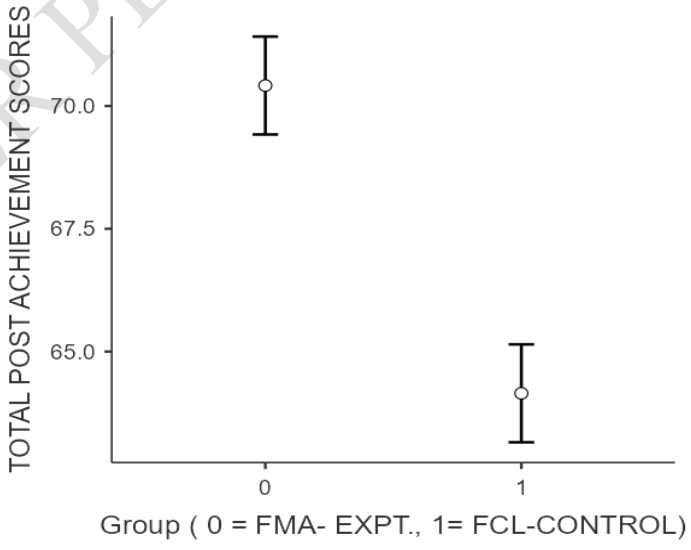
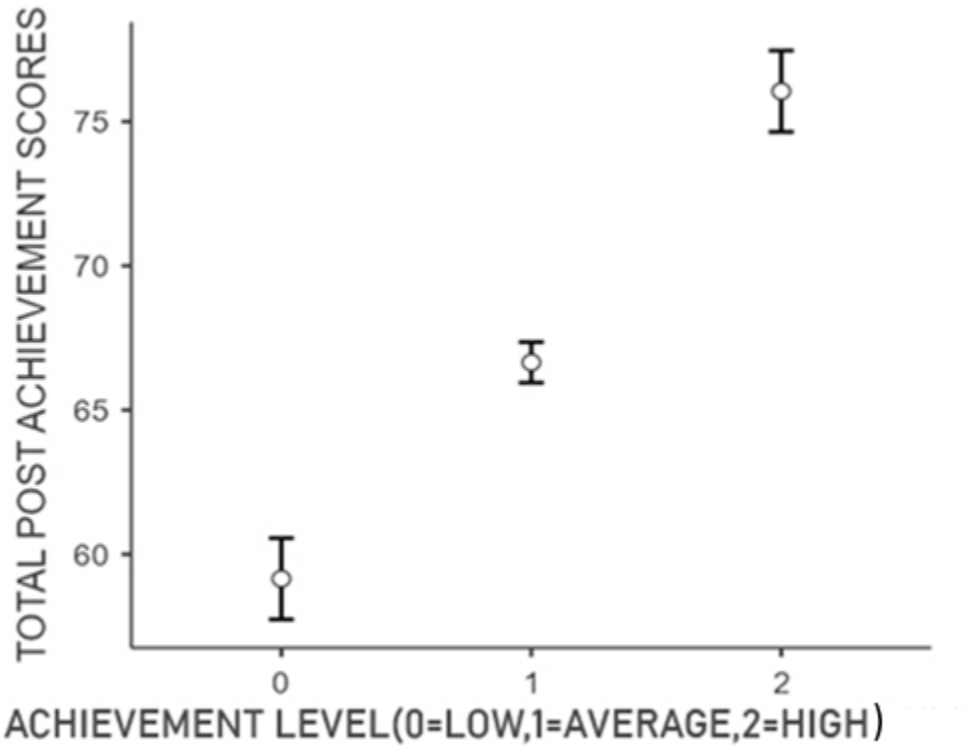


Table 9. Post- hoc comparison of with in group interaction ofprevious knowledge level and post test score.

Group (0-low,1middle,2 higher)	**Mean Difference**	**SE**	**df**	**t**	**p_{tukey}**
0----- 1	-7.5	0.796	114	-9.43	< .001
0 -------2	-16.9	1.006	114	-16.79	< .001
1 -------2	-9.4	0.796	114	-11.82	< .001

Graph 3. Comparison graph w.r.t previous knowledge level.



The ANOVA results underscore the considerable impact of both the instructional approaches (Flipped Mastery ApproachandFlipped Classroom Learning) and participants' previous knowledge levels on total post-achievement scores. In table 8, the mean difference between two

groups is 6.27 indicating ahigh impact ofthe experimental method on achievement. The t- value is 8.81 with a p- value <.001, showing that the impact is significant.

Three groups with varying degrees of prior knowledge are compared in the table 9. This demonstrates that students often perform better when they are more knowledgeable about a subject before studying it. Academic success increases in tandem with the amount of prior knowledge.

Table 10. Post-hoc comparison of between groups: Method of teaching and previous knowledge level on post test score.

Group	**Mean Difference**	**SE**	**df**	**t**	p_{tukey}
0 -- 0 (Ex - Low) – 0 – 1 (Ex - Middle)	-5.65	1.125	114	-5.022	< .001
0 -- 0 (Ex - Low) – 0 – 2 (Ex - High)	-13.9	1.423	114	-9.767	< .001
0 -- 0 (Ex - Low) – 1 – 0 (Con - Low)	9.5	1.423	114	6.675	< .001
0 -- 0 (Ex - Low) – 1 – 1 (Con - Middle)	0.15	1.125	114	0.133	1
0 -- 0 (Ex - Low) – 1 – 2 (Con - High)	-10.4	1.423	114	-7.308	< .001
0 -- 1 (Ex - Middle) – 0 – 2(Ex-High)	-8.25	1.125	114	-7.333	< .001
0 -- 1 (Ex - Middle) – 1 – 0 (Con - Low)	15.15	1.125	114	13.466	< .001
0 -- 1(Ex - Middle) –1– 1(Con - Middle)	5.8	0.712	114	8.151	< .001
0 - 1 (Ex - Middle) – 1 – 2 (Con - High)	-4.75	1.125	114	-4.222	< .001
0 -- 2 (Ex - High) – 1 – 0 (Con - Low)	23.4	1.423	114	16.443	< .001
0 -- 2(Ex - High) – 1 – 1 (Con - Middle)	14.05	1.125	114	12.488	< .001
0 -- 2 (Ex - High) – 1 – 2(Con - High)	3.5	1.423	114	2.459	0.145
1-- 0(Con - Low) –1 – 1 (Con - Middle)	-9.35	1.125	114	-8.311	< .001
1-- 0 (Con - Low) – 1 – 2 (Con - High)	-19.9	1.423	114	-13.983	< .001
1--1 (Con- Middle) –1 – 2 (Con - High)	-10.55	1.125	114	-9.377	< .001

Graph 4.Interaction Graph w.r.t method of teaching and previous knowledge level

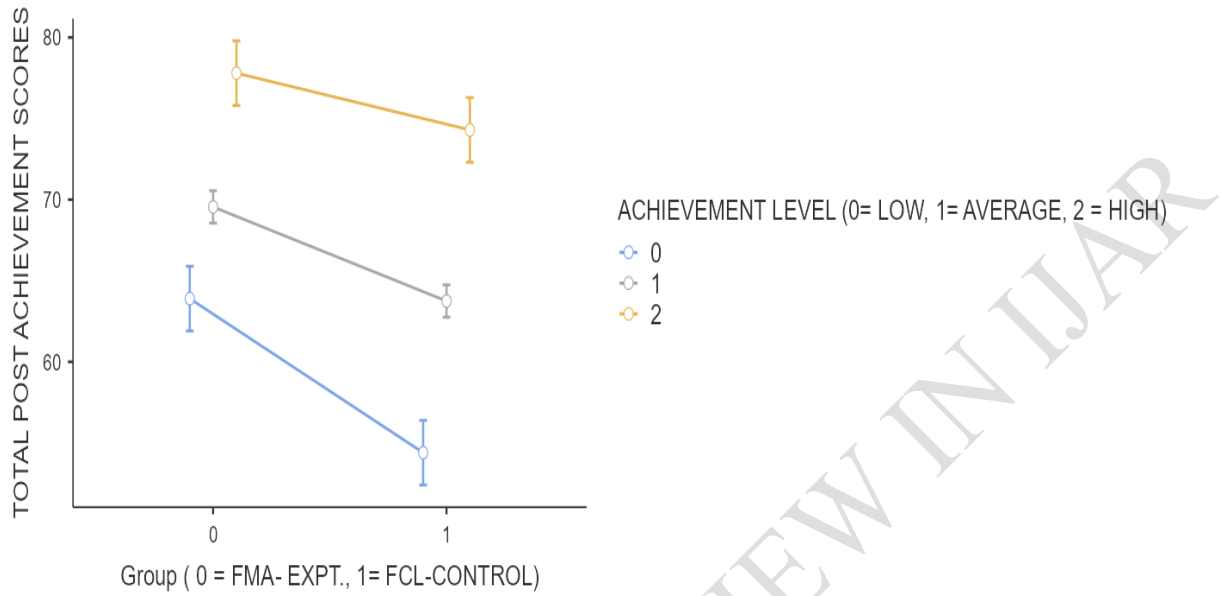


Table 10 presents post hoc comparisons between the two groups: the Flipped Mastery Approach-experimental group (FMA-EXPT, Group 0) and the Flipped Classroom Learning - control group (FCL-CONTROL, Group 1), across different levels of previous knowledge (low, medium, and high). The mean difference, standard error (SE), degrees of freedom (df), t-value, and p-value (ptukey) were provided for each comparison.Several comparisons are notable in the table. When comparing different previous knowledge levels within the flipped mastery approach group (group 0), significant differences emerged.In this context, individuals with high previous knowledge level (level 2) fared noticeably better than those with low previous knowledge level (level 0) and average level (level 1). Likewise, those with average level did noticeably better than those with low previous knowledge level. The outcomes for the flipped classroom learning group (Group 1) were also similar. Pupils with high prior knowledge levels outperformed those with low and medium prior knowledge levels. Furthermore, pupils with medium level of prior knowledge performed noticeably better than ,those with lower level.

The experimental group (FMA, group 0) consistently outperformed the control group (FCL, group 1) across all levels of previous knowledge, according to the post-hoc test of between-group comparison. Taking into account table no. 10, the mean difference was negative for each level, indicating that group 0's score was high. The low p values (<.001) for these scores suggest that the differences were statistically significant. These findings demonstrate how well the flipped mastery method outperforms flipped classroom instruction in biology achievement across all previous knowledge levels. Group 0 (FMA) students with low previous knowledge level scored better than students in Group 1 at the same level. Likewise, group 0 outperformed group 1 at the medium and upper levels of previous knowledge as well, demonstrating the potential of FMA across all levels.

.

RESULT AND DISCUSSION

The Flipped Mastery Approach is more helpful since it enables students to completely understand each concept (80%) before moving on to the next topic, even if it and flipped classroom learning follow the same procedural pattern in their implementation.The findings of this research highlight the great potential of flipped mastery approach to support students' academic success. This approach takes individual differences into account more thoroughly while assessing the instructional interventions. Despite the poor prior knowledge level, FMA helps the students understand the topic from the ground up through a variety of exercises and repetitions until the concept becomes clear. The findings also suggest that students will do better if they have a strong foundation in the subject matter.The results of the present study are consistent with those of Bergman and Aron(2016), who reported that students who participated in the flipped mastery approach experienced a significant difference.

The current study shows that flipped mastery is more successful when it comes to long-term retention of the concept learned, especially for subjects such as biology. A notion is retained in memory for a longer period after mastery through activities. Bala published a supporting finding that demonstrated a significant difference between the post-test mean scores of the Experimental group (mastery learning) and the Control group (conventional method) in the achievement test.(Bala, 2020)Despite being taught via activities, a concept may not be retained for a longer period of time if it is not fully understood.Therefore, the experimental group's students who were taught using the FMA method outperformed the control group, which was taught using the FCL method, by a significant margin.The findings of the ANOVA show that teaching approach has a significant impact on the overall achievement score, with the flipped Mastery Approach achieving a much higher score than flipped classroom learning. This was made feasible by the availability of content repetition, both in and out of the classroom, until the material was mastered.(Kuliket al., 1990)found that students who used themastery learning technique experienced a significant difference, which is in line with the findings of this study.

Furthermore, participants' total performance was greatly influenced by their prior knowledge of the subject, which was divided into three categories: low, medium, and high. Better knowledge levels were associated with better post-achievement score. The findings of the current study are in line with those of Damavandi and Shekari, who found that students who used the mastery technique were significantly different from those who used the traditional method.It goes without saying that if students understand the fundamentals of a given idea, it will be simple to incorporate new information into their existing understanding, thereby simplifying the learning process.(Damavandi & Shekari, 2010)The study reveals significant differences in the score of students in different previous knowledge levels within the flipped mastery approach and flipped classroom learning groups. Participants with a low level of previous knowledge in the experimental group outperformed those with similar levels in the control group. A similar trend was visible in the other levels also. This indicates the efficiency of flipped mastery approach in understanding the concepts.The study found that participants in the flipped mastery approach (Group 0) consistently outperformed those in the flipped classroom learning group (Group 1)

across all three levels of previous knowledge (Bergman,2016).These statistically significant differences were attributed to the use of low p-values. The results also showed that participants with lower previous knowledge levels performed better, indicating the potential of the flipped mastery approach.

Conclusion

Flipped mastery will be the best approach to achieve NEP 2020's inclusive education goal because it takes into account each student's unique learning style and pace.The primary goal of the current study was to determine how well the flipped mastery approach strategy affects standard XI biology students' learning performance in order to improve their comprehension of the material and retention of the concepts learned for a longer time to help them receive high exam scores. The results of the study clearly showed that the experimental group's mean scores on the post-test increased significantly. When compared to students in the control group who were taught using the simple flipped method of instruction, the experimental group that was exposed to flipped masterystrategies demonstrated superior learning performance. Because flipping when combined with mastery approach extends education outside the physical boundaries of the classroom and sets time periods for the school doors, it enhances learners' autonomy, higher order thinking abilities, effective communication skills, technical literacy, and confidence, among other things.Even for sluggish learners, flipping becomes the most effective method when combined with mastery learning because it enables them to go over the material again and again.This approach guarantees the mastery of every subject, which will also aid pupils who have forgotten the material or who did not comprehend it in earlier grades.

REFERENCES

https://www.reallygoodinnovation.com/stories/what-is-the-importance-of-innovation-in-education

Adams, A. E. M., Garcia, J., & Traustadóttir, T. (2016). A quasi experiment to determine the effectiveness of a "Partially flipped" versus "Fully flipped" undergraduate class in genetics and evolution. *CBE Life Sciences Education*, *15*(2). https://doi.org/10.1187/CBE.15-07-0157

Alsalhi, N. R., Al-Qatawneh, S., Eltahir, M., & Aqel, K. (2021). Does Blended Learning Improve the Academic Achievement of Undergraduate Students in the Mathematics Course?: A Case Study in Higher Education. *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(3), 1–14. https://doi.org/10.29333/EJMSTE/10781

Bala, P. (2020). Impact of multimedia and mastery learning approaches on achievement in mathematics in relation to interest among fifth class students with mathematical difficulties. *University*. http://hdl.handle.net/10603/442625

Bergmann, J., & Sams, A. (2012). *Flip Your Classroom: Reach Every Student in Every Class Every Day*. www.iste.org/learn/publications/permissions

Bhagat, K. K., Chang, C. N., & Chang, C. Y. (2016). The impact of the flipped classroom on mathematics concept learning in high school. *Educational Technology and Society*, *19*(3), 134–142.

Bishop, J. L., & Verleger, M. A. (2013). The flipped classroom: A survey of the research. *ASEE Annual Conference and Exposition, Conference Proceedings*. https://doi.org/10.18260/1-2--22585

Bong, J., Cho, K., Liu, Z., & He, D. (2023). A dual-process motivation mediation model to explain female high school students' cognitive engagement and disengagement in emergency remote teaching and online learning in South Korea. *British Journal of Educational Technology*, *55*. https://doi.org/10.1111/bjet.13415

Ceker, Eser, Fezile Ozdamli, D. (2016). Features and characteristics of problem based learning Eser. *Cypriot Journal of Educational Sciences*, *11*,(4), 195–202.

Cho, M.-K., & Kim, M. (2019). Outcomes and influential factors applying flipped learning methods in a clinical adult nursing practicum: Effects of flipped-learning in nursing practicums. *International Journal of Nursing Practice*, *25*, e12724. https://doi.org/10.1111/ijn.12724

Damavandi, M. E., & Shekari, Z. (2010). *Effect of mastery learning method on performance and attitude of the weak students in chemistry*. *5*, 1574–1579. https://doi.org/10.1016/j.sbspro.2010.07.327

Diem, H. T. T., Thinh, M. P., & Lam, V. T. T. (2024). Exploring Practical Pedagogy in High School Biology Education: A Qualitative Study of Pre-Service Biology Teachers' Experiences in Vietnam. *Başlık*, *volume-13*-(volume-13-issue-2-april-2024), 557–571. https://doi.org/10.12973/eu-jer.13.2.557

Dİnçer, N., & Polat, M. (2022). The Use of Flipped Learning in EFL Grammar Instruction. *Asian Journal of Distance Education*, *17*(1), 88–108.

Förster, M., Maur, A., Weiser, C., & Winkel, K. (2022). Pre-class video watching fosters achievement and knowledge retention in a flipped classroom. *Computers & Education*, *179*, 104399. https://doi.org/10.1016/J.COMPEDU.2021.104399

Gayatri. (2019). *Effectiveness Of Flipped Classroom Strategies On Enhancing Learning Performance Of Chemistry And In Certain Selected Variables Among The Students Of Standard Xi*. http://hdl.handle.net/10603/299926

González-Gómez, D., Jeong, J. S., Airado Rodríguez, D., & Cañada-Cañada, F. (2016). Performance and Perception in the Flipped Learning Model: An Initial Approach to Evaluate the Effectiveness of a New Teaching Methodology in a General Science Classroom. *Journal of Science Education and Technology*, *25*(3), 450–459. https://doi.org/10.1007/s10956-016-9605-9

Hajari, B. (2016). *Study of the Effectiveness of Flipped Classroom Strategy for Enhancing Achievement in Science among Secondary School Studentstle* [University of Mumbai]. http://hdl.handle.net/10603/282959

Khanday, S., & Khanam, D. (2023). *THE RESEARCH DESIGN*. *06*, 376.

Kulik, C. L. C., Kulik, J. A., & Bangert-Drowns, R. L. (1990). Effectiveness of Mastery Learning Programs: A Meta-Analysis. *Review of Educational Research*, *60*(2), 265–299. https://doi.org/10.3102/00346543060002265

Latha, R. (2020). *Effectiveness of Flipped Learning and Blended Learning on Achievement in Computer Science Among XI Standard Students* [Tamil Nadu Teachers Education University]. http://hdl.handle.net/10603/347002

Lin, Y.-N., Hsia, L.-H., Sung, M.-Y., & Hwang, G.-H. (2019). Effects of integrating mobile technology-assisted peer assessment into flipped learning on students' dance skills and self-efficacy. *Interactive Learning Environments*, *27*(8), 995–1010. https://doi.org/10.1080/10494820.2018.1461115

Madhuri, E. S. (2024). *Learning Styles Of Secondary School Students Their Interest And Achievement In Biological Science In Visakhapatnam District* [Andhra University]. http://hdl.handle.net/10603/570257

Malto, G. A. O., Dalida, C. S., & Lagunzad, C. G. B. (2018). Flipped Classroom Approach in Teaching Biology: Assessing Students' Academic Achievement and Attitude Towards Biology. *KnE Social Sciences*, *3*(6), 540. https://doi.org/10.18502/KSS.V3I6.2403

Matawali, A., Bakri, S. N. S., Jumat, N. R., Ismail, I. H., Arshad, S. E., & Din, W. A. (2019). The preliminary study on inverted problem-based learning in biology among science foundation students. *International Journal of Evaluation and Research in Education*, *8*(4), 713–718. https://doi.org/10.11591/ijere.v8i4.20294

Mohamad Said, M. N. H. Bin, & Zainal, R. (2017). A Review of Impacts and Challenges of Flipped-Mastery Classroom. *Advanced Science Letters*, *23*, 7763–7766. https://doi.org/10.1166/asl.2017.9571

Nair, T. ., & R.L, B. (2016). *Effect of Blended Learning Strategy on Achievement in Biology and Social and Environmental Attitude of Students at Secondary Level.11*(4), 39–52.

Parikh, L. (2024). *A Study of Learning Difficulties in Biology Subject of Secondary School Students in Gandhinagar District* [Sabarmati University]. http://hdl.handle.net/10603/593613

Patel, S.(2021). Effect of co_operative and mastery learning approach of teaching science in scientific attitude and academic achievement of secondary school studentshttp://hdl.handle.net/10603/374279

R.Preethi. (2019). *English Language Teaching Techno Pedagogy Flipped Classrooms and M Learning to teach Writing Skills at the Tertiary Level* [University of Madras]. http://hdl.handle.net/10603/229393

Rahman,S.R.,Islam, A., Akash, P.P., Parvin, M., Moon, N.N.,&Nur, F.N. (2021). Effects of co-curricular activities on student's academic performance by machine learning.

Current Research in Behavioral Sciences, 2,https://doi.org/10.1016/j.crbeha.2021.100057

Skovsgaard, J. (2018). The Future of Education and Skills: Education 2030. *OECD Education Working Papers*, 1–23. http://www.oecd.org/education/2030/E2030%0APosition%0APaper%0A(05.04.2018).pdf