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

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1
2 **Innovative Teaching Strategies in Biology: Assessing Flipped Mastery vs. Flipped**
3 **Classroom Learning**
4
5
6
7 **ABSTRACT**
8
9   The current study examined the efficacy of Flipped Mastery Approach (FMA) and Flipped
10   Classroom Learning (FCL) in helping 11th grade students grasp biology subjects based on
11   differences in their previous knowledge levels. The study included a sample of 120 class 11
12   learners from the Indian state of Jharkhand, including 60 students in each of the
13   experimental and control groups. In terms of the post-achievement score, the experimental
14   group (FMA) fared better than the control group (FCL). The FMA approach was proven to
15   be successful in helping low-achievers retain complex biological concepts over the long
16   term.The ANOVA findings also showed that the type of teaching used to transfer the
17   information impacts performance in a given topic, with FMA yielding better scores than
18   FCL. This was ascribed to FMA's make available for students to see instructional films and
19   complete topic-related activities many times until they attained 80% mastery of the
20   material. Additionally, the students' prior knowledge concerning a given subject had an
21   effect on their total performance. Students with greater prior knowledge levels were shown
22   to have higher post-achievement scores in this study.Additionally, the study discovered that
23   students in the FMA and FCL groups with varied degrees of prior knowledge scored
24   substantially differently, with FMA consistently outperforming FCL across the board. These
25   findings illustrate how FMA might aid students with lower previous knowledge levels in
26   comprehending and remembering topics over time, as well as the significance of taking
27   individual differences in achievement levels into account when evaluating instructional
28   interventions.
29
30
31 **Keywords:-**
32 Flipped Mastery Approach, Flipped Classroom Learning, Previous knowledge level, Retention
33 capacity
34
35 **Introduction**
36 Since education is a continuous process, it occasionally needs to be updated to meet the
37   shiftingdemands of society in order to advance. A nation can address these demands by
38   implementing novel and revolutionary modifications to the classroom teaching approach,
39   which will encourage students' creativity and critical thinking.This involves introducing
40   new ideas, processes, and tactics while encouraging inquiry, problem-solving, and
41   discovery. According to (Skovsgaard, 2018), schools in the 21st century must prepare
42   students   for   a   rapidly   changing   world   economically,   socially,   and
43   technologically.Technology-integrated education, which provides limitless resources, is one
44   of the preferred approaches to education. The flipped classroom learning (FCL), a novel
45   approach that is student-oriented, self-paced and technology integrated. Developed by
46   Bergman and Aaron (Bergmann & Sams, 2012) for students who cannot attend school

1

47 regularly, flipped learning has gained traction as a successful teaching method and trend in
48 the past decade (Ceker, Eser, Fezile Ozdamli, 2016). The primary goal of flipped learning is
49 to increase the amount of time teachers and students spend together in the classroom,
50 whereas most conventional classroom instructors used it for lectures. However, according to
51 Sams and Bergmann (2013), instructors should use the upper level of Bloom's Taxonomy
52 for face-to-face instruction, while the lower level should be used outside of the classroom.
53 Teachers appear to have several responsibilities. After reading the relevant literature, the
54 researcher believes that flipped learning is a fantastic method for enhancing achievement,
55 interest, motivation, and attitude towards the subject. Most studies were conducted with
56 undergraduate students.(Matawali etal,2019;Alsalhi et al., 2021;DĪnçer & Polat,
57 2022;Förster et al., 2022). Many investigators have experimented with this technique with
58 higher-secondary students in the fields of computer science, physics, and chemistry.
59 (Preethi, 2019; Gayatri, 2019;Latha, 2020). Several research studies have shown that this
60 method is advantageous for acquiring biological knowledge in middle and high schools, as
61 well as for B.Ed. students. (Adams et al., 2016; Nair and Bindu, 2016;Malto et al.,
62 2018;Bishop and Verleger, 2013). Parallel strategies such as blended and inverted learning
63 have been found to be beneficial in the field of higher secondary biology education.
64 (González-Gómez et al., 2016;Nair and R.L, 2016;Matawali et al., 2019). Bergman and
65 Aron, the creators of flipped learning, discovered that when they combined this approach
66 with mastery learning, chemistry students learned more effectively than the normal flipped
67 learning.
68
Literature Review:
70
71 According to the analysis of Parikh, the nature of the subject, the way teachers teach,
72 unfavorable sentiments and attitudes towards the subject because of a lack of concept clearances,
73 a lack of resources, interest, and insufficient information about the topic's value in career
74 development are the main causes of learning difficulties in biology classes (Parikh, 2024).The
75 teaching methods used in higher secondary classes may not adequately capture students'
76 attention or foster genuine curiosity about biological concepts. Additionally, the pressure of
77 exams and rote memorization often associated with biology courses can discourage students
78 from developing genuine passion for the subject. The issue of disengagement in biology at the
79 higher secondary level is multifaceted, with various studies highlighting the different
80 contributing factors and potential strategies to address this problem.Using a variety of teaching
81 techniques and tactics that accommodate diverse learning styles helps increase students' interest
82 in a subject and their involvement in the learning process. According to their preferred learning
83 styles, students that actively engage in the educational process can attain highin the learning
84 process. (Madhuri, 2024).Results of the study conducted by Bong in South Korean high schools,
85 showed that cognitive engagement and disengagement were predicted by the exogenous factors
86 such as perceived autonomy support, perceived teacher control, and technological self-efficacy
87 (Bong et al, 2023). Innovative teaching methods for student involvement are highlighted in the
88 research, by Diem , among pre service biology teachers in Vietnam, which emphasizes obstacles
89 in integrating theoretical knowledge with classroom practice. In order to better prepare pre-
90 service teachers for their professional path, the program places a strong emphasis on experiential
91 learning through teaching apprenticeships, reform and other areas (Diem et al.,2024).In
92 conclusion, a number of issues, such as curriculum deficiencies, teacher effectiveness, their

2

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)

3

139
140 .
141 The most alluring aspect of this innovative approach is that it permits students study the material
142 at their own speed and interest. It enables pupils to grasp one idea before going on to the next
143 (Bergmann&Aron,2012).The flipped mastery technique may accommodate each student's needs
144 to expand their understanding of the subject. Above all, this approach has the potential to
145 strengthen students' 21st century abilities, including critical and creative thinking, teamwork, and
146 problem-solving, all of which are crucial for biology learning. However, in order to achieve the
147 intended learning objectives, creating a good lesson plan for this technique requires the teacher's
148 creativity as well as thorough planning and preparation of the subject matter and related
149 activities.By examining the efficacy of the flipped Mastery Approach in eleventh-grade biology
150 and evaluating whether it was more successful than flipped classroom learning in transferring
151 content, the researcher discovered a gap in this field. This study aimed to determine the
152 effectiveness of flipped learning and flipped mastery learning approaches in biology
153 achievement among eleventh-grade students.
154
155 The research questions were as follows.
156 1. How does the implementation of Flipped Mastery approach impact biology achievement
157 among eleventh-grade students?
158 2. Which method is better in the transaction of learning content in 11th grade biology – Flipped
159 Classroom Learning (FCL) or FlippedMastery Approach(FMA)?
160 3. To what extent does Flipped Mastery Approach enhance content retention in biology learning
161 for eleventh-grade students?
162 4. Does the interaction of teaching methods (FMA and FCL) and student's previous knowledge
163 levels significantly affect their achievement in biology, as measured by post-test scores?
164

Materials and methods

166 Methodology serves as a framework for conducting scientific research. This constitutes the
167 researcher's plan to conduct the study. It delineates the methods and procedures used to conduct
168 the study, including sample selection, data collection, and analysis. It is a systematic approach by
169 which scientists plan their investigation to enable them to use the chosen research tools to
170 accomplish their objectives. It encompasses all critical aspects of research, including the
171 overarching framework for the study as well as the methodologies employed for data collection,
172 analysis, and research design (Khanday & Khanam, 2023). A quasi-experimental design was
173 employed in the present study.A well-designed study should encompass a precise and well-
174 defined research question, methodology for data collection, andtechnique for analysis and
175 interpretation of the findings. All of these aspects were addressed through a carefully considered
176 study design. The researcher selected anexperimental - control group, Post-Test design for the
177 current investigation.
178

Variables of the study

180 A. Independent variable
181   • Flipped Mastery Approach
182   • Flipped Classroom Learning
183 B. Dependent Variable
184   • Achievement in Biology

4

185   C. Intervening Variable
186   • Previous knowledge Level
187   The intervening variable was controlled by administering a pre – test based on the
188   10th class syllabus on photosynthesis and respiration in the plants. Based onthe
189   pre-test scores, students in each group were divided into three subgroups: -
190   low,average and high level (Stream, Mountain and Sky respectively).
191
192
193 **SAMPLE**
194
195 A sample of 120 standard XI Biology students was selected from two schools, Mar Gregorios
196 Memorial Higher Secondary School and Holy Cross School in the district of Bokaro Steel City,
197 Jharkhand State.The researcher used entire sections of the two schools' class 11 as a purposive
198 sample.This procedure allocated the subjects into two groups: control and experimental. The
199 experimental group was taught using the Flipped Mastery Approach, while the control group
200 received instruction using the normal Flipped Classroom Learning method.Each group was
201 further divided into three categories according to their previous knowledge level of the topic —
202 low achievers (stream), medium achievers (mountain), and high achievers(sky) —based on the
203 score of a pre-test administered to each group.
204
205 *Table 3.1 Experimental Control Group Post-Test Design*
206

Group	Treatment	Post-test
Experimental	Xe	O_1
Control	X_c	O_2

207
208    $X_e \rightarrow$ Experimental treatment given
209 $X_c \rightarrow$ Conventional treatment given
210   Comparison of O_1 and O_2 :- $O_1 - O_2$
211

212 **FINDINGS OF THE STUDY**

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

221 *Table 1. Group Descriptives in Pre-Test Score*

5

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

222

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

224

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

225

226

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

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

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

246

247   *Table 3. Group descriptives of Post Test Score*

6

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

248

249 When examining post-achievement scores, the Flipped Mastery Approach group had a mean of
250 70 and a median of 70, with an SD of 4.87 and an SE of 0.628. The Flipped Classroom Learning
251 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,
252 the Flipped Mastery Approach group demonstrated higher overall achievement than the Flipped
253 Classroom Learning group. An independent sample t- test analysis revealed statistically
254 significant differences between the groups. (Table 4)

255

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

257

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

258

259 For the post achievement scores, the t-value was 5.59 with 118 degrees of freedom and a p-value
260 of less than .001, indicating a statistically significant difference. The mean difference here was
261 6.03 with a standard error of 1.08. This finding suggests that the achievement scores between the
262 two groups differed considerably, with a larger mean difference and higher standard error in
263 favor of the Flipped Mastery Approach Group.

264

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

270

271

272

273

274 *Table 5. Group descriptives of Delayed Post-Test Score*

7

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

275

276   *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

277   Descriptive statistics of the performance of the two groups are presented in table 5 in terms of
278   their delayed achievement scores between groups 0 (flipped mastery) and 1 (flipped classroom).
279   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,
280   Group 1 has a mean score of 70.6, median of 71, SD of 8.76, and SE of 1.131. This indicates a
281   higher overall performance in delayed achievement for participants in the flipped mastery
282   approach group compared to those in the flipped classroom learning group. The t-test statistic is
283   8.09 with 118 dfand a p-value of less than .001, demonstrating a significant difference between
284   the two groups. The mean difference was 11.07 and SEwas 1.369. (Table 6) This remarkable
285   mean difference indicates that the overall performance in delayed achievement scores was
286   superior when using flipped mastery over flipped classroom learning.The graph below depicts
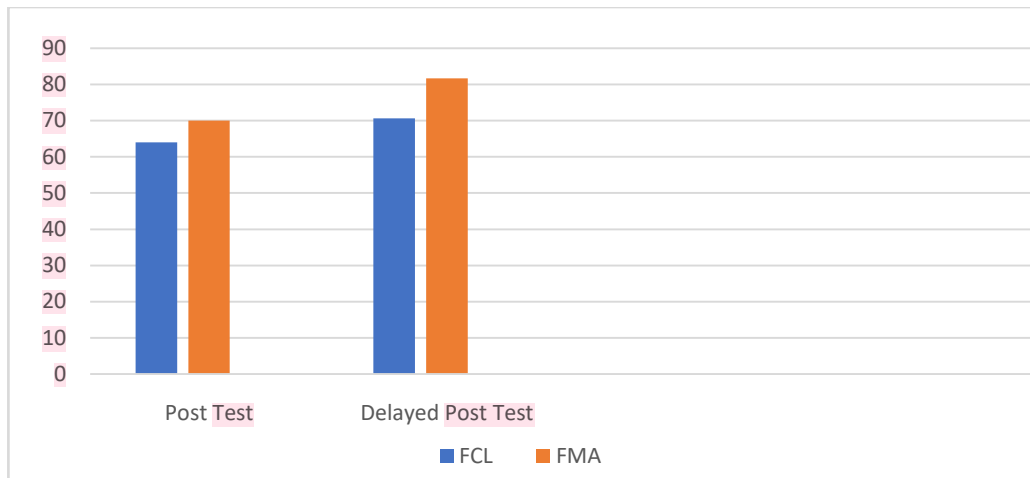287   the comparison of FCL and FMA in the post test and delayed post- test.

288

289

290

291

292

293

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

8

295

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

300
301
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.

9

311 Second, the analysis revealed a substantial main effect of the level of previous knowledge on
312 total post-achievement scores, F (2, 114) = 142.21, p < .001. This suggests that participants' level
313 of previous knowledge on the topic , categorized as low, medium and high, significantly impact
314 ed their overall performance, with higher knowledge levels correlating with higher post-
315 achievement scores.
316 Furthermore, the effect of the interactionbetween themethod of teaching and previous
317 knowledgeon achievement also exhibited significance, F(2, 114) = 4.61, p = 0.012. This
318 interaction effect suggests that the relationship between the method of teaching and the level of
319 previous knowledge is not uniform across all levels, indicating a nuanced influence of the
320 instructional approach on achievement outcomes depending on the participants' initial
321 knowledge levels.
322 The result of analysis of post-hoc comparison for with in group interaction to determine the
323 particular group that differs significantly is presented in the table given below.
324
325 *Table 8. Post-hoc comparison of with in group interaction of method of teaching on post test*
326 *score.*
327

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

328
329 *Graph 2. Comparison graph w.r.t method of teaching*
330

331

10

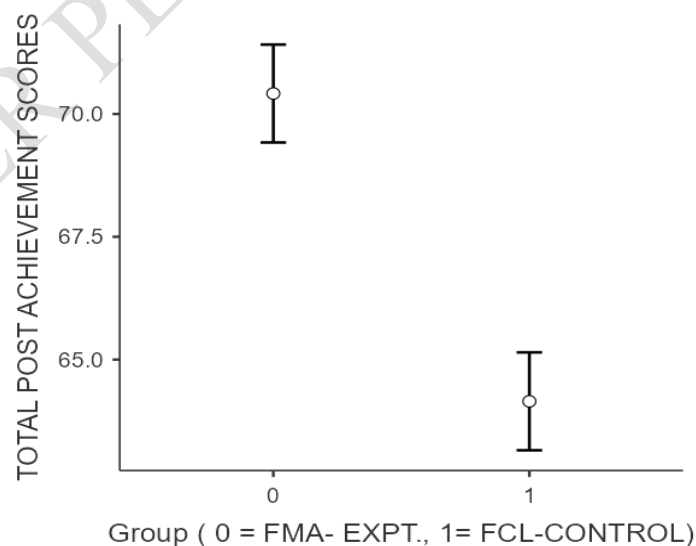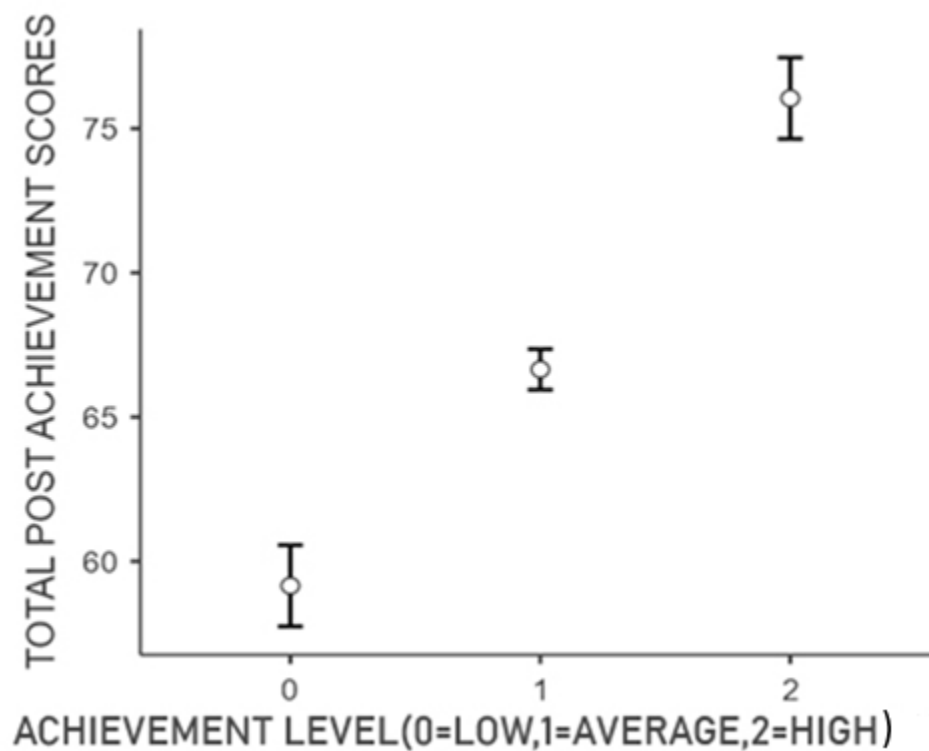332   *Table 9. Post- hoc comparison of with in group interaction ofprevious knowledge level and post*
333   *test score.*

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

334

335

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

337
338
339   The ANOVA results underscore the considerable impact of both the instructional approaches
340   (Flipped Mastery ApproachandFlipped Classroom Learning) and participants' previous
341   knowledge levels on total post-achievement scores. In table 8, the mean difference between two

11

342 groups is 6.27 indicating a high impact of the experimental method on achievement. The t- value
343 is 8.81 with a p- value <.001, showing that the impact is significant.
344 Three groups with varying degrees of prior knowledge are compared in the table 9. This
345 demonstrates that students often perform better when they are more knowledgeable about a
346 subject before studying it. Academic success increases in tandem with the amount of prior
347 knowledge.
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349 *Table 10. Post-hoc comparison of between groups: Method of teaching and previous knowledge*
350 *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

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356   *Graph 4.Interaction Graph w.r.t method of teaching and previous knowledge level*
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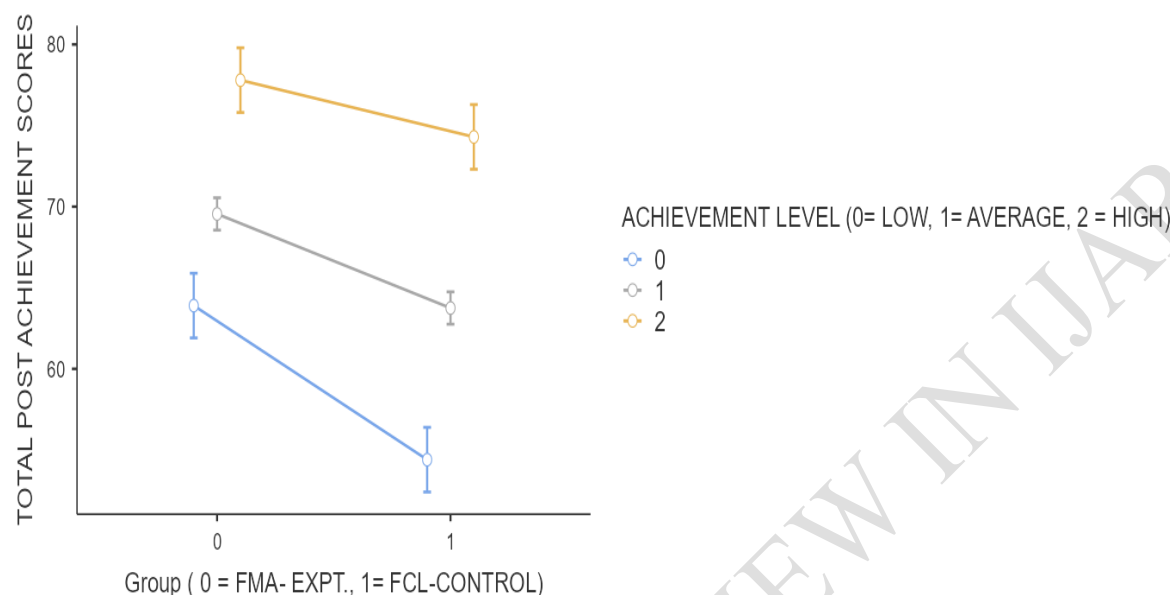Group (0 = FMA- EXPT., 1= FCL-CONTROL)

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361   Table 10 presents post hoc comparisons between the two groups: the Flipped Mastery Approach-
362   experimental group (FMA-EXPT, Group 0) and the Flipped Classroom Learning - control
363   group (FCL-CONTROL, Group 1), across different levels of previous knowledge (low,
364   medium, and high). The mean difference, standard error (SE), degrees of freedom (df), t-
365   value, and p-value (ptukey) were provided for each comparison.Several comparisons are
366   notable in the table. When comparing different previous knowledge levels within the
367   flipped mastery approach group (group 0), significant differences emerged.In this context,
368   individuals with high previous knowledge level (level 2) fared noticeably better than those
369   with low previous knowledge level (level 0) and average level (level 1). Likewise, those
370   with average level did noticeably better than those with low previous knowledge level. The
371   outcomes for the flipped classroom learning group (Group 1) were also similar.
372   Pupils with high prior knowledge levels outperformed those with low and medium prior
373   knowledge levels. Furthermore, pupils with medium level of prior knowledge performed
374   noticeably better than ,those with lower level.
375   The experimental group (FMA, group 0) consistently outperformed the control group (FCL,
376   group 1) across all levels of previous knowledge, according to the post-hoc test of between-
377   group comparison. Taking into account table no. 10, the mean difference was negative for
378   each level, indicating that group 0's score was high. The low p values (<.001) for these
379   scores suggest that the differences were statistically significant. These findings demonstrate
380   how well the flipped mastery method outperforms flipped classroom instruction in biology
381   achievement across all previous knowledge levels. Group 0 (FMA) students with
382   low previous knowledge level scored better than students in Group 1 at the same level.
383   Likewise, group 0 outperformed group 1 at the medium and upper levels of previous
384   knowledge as well, demonstrating the potential of FMA across all levels.

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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)

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

437 **Conclusion**

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

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