Effect of Gamified Flipped Learning Strategy on Achievement and Attitudes of Pre-Service Teachers on Genetic Concepts, At College of Education in Anambra State, Nigeria

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ABSTRACT

Biology plays a crucial role in scientific and technological advancement of a nation. To achieve this, students must have a strong grasp of biological concepts and as well develop a positive attitude towards the subject. This study therefore investigated the effect of gamified flipped learning strategy on the achievement and attitude towards genetic concepts among pre-service teachers at college of education, Anambra State, Nigeria. It also examined the moderating effect of gender on the attitude and achievement. The study adopted a pre-test-post-test control group quasi-experimental research design of 2×2×2 factorial matrix, with a sample of 150 intact classes (70 males and 80 females). The instrument used for data collection were Genetic Achievement Test (GAT) and treatment material was Gamified Flipped Instructional Package (GFIP) and, Questionnaire on Students' Attitude to Biology (QSAB). The experimental group were taught using Gamified Flipped Instructional Package which Comprised of Genetic Lesson, while the control group were exposed to Lecture Method (LM). Mean and standard deviations were used to answer research questions while ANCOVA was used to test hypothesis at 0.05 level of significance. The results revealed that gamified flipped Instructional strategy significantly improved students' academic achievement and also showed significant effect on attitude of pre-service teachers towards biology. However, Gender does not significantly affect pre-service teachers' achievement and attitude in biology. The study therefore concluded at this point that gamified flipped learning approach is one of the effective instructional approaches to teach biology, particularly, "Genetic" concepts and other science related concepts, because it creates room for collaboration, creativity and critical thinking. It was recommended that educators should adopt gamified flipped instructional strategy in teaching of biology.

Keywords: Flipped learning Approach, Gamification Approach, and Genetics**.**

INTRODUCTION

For a country to grow and advance, education is essential. Education is seen as a tool for a country's development and change. However, a country's degree of national growth and advancement is determined by the caliber of its educational system. The nation's level of accomplishment and growth is determined by the delivery of educational services, which is why educators, the government, and other stakeholders in education place a strong emphasis on it. Since the introduction of technology has raised living standards and had a significant impact on every area of daily life, including the home, workplace, school, and marketplace, the importance of science and technology education in bringing about social change cannot be overstated (Gambari &Ajanaku, 2019). Education in science and technology is given significant priority. The importance of science and technology to human existence and national development makes science and technology education a top priority. According to Baba (2017), education in science and technology is essential for every country to progress.

One of the most important contributions to a country's technological growth is biology, a branch of science and prerequisite for many other fields of study, including agriculture, pharmacy, botany, medicine, nursing, and biotechnology. According to Sallau and Bello (2019), biology education in both senior secondary and postsecondary educational institutions equips students with important ideas, theories, and concepts that help

them deal with life's obstacles even after they graduate. A basic grasp of every facet of life on earth is derived by studying biology.

Moreover, the area of biology known as genetics focuses on the study of genes, genetic diversity, and inheritance in living things. The study of genetics focuses on the inheritance of characteristics from one generation to the next, including the process of gene expression and the transfer of genetic information through DNA. To comprehend the processes of heredity, evolution, and the function of genes in disease, one must study genetics. Genetics has significant effects in many areas, such as biotechnology, agriculture, and medicine. The distinctive characteristics of living things are greatly influenced by genetics, which also sheds light on the molecular mechanisms regulating biological activities. However, studies conducted recently have revealed that passing the subject at both the Senior School Certificate Examination (NECO) and the West Africa Secondary School Certificate Examination (WASSCE) is becoming more and more challenging for students in recent years. As a result, the Chief Examiners of WAEC and NECO have consistently expressed their concerns about the poor performance of candidates in biology, using phrases like "not satisfactory," "downward trend," "decline in pass rate," and "fluctuating performance," in their reports. This is consistent with the fourteen years of statistical analysis of students' performance in the SSCE biology from 2010 to 2023, which revealed a "decline in pass rate" of students (Piwuna and Mangut, 2023; Okanume, 2024).

Furthermore, some biological ideas may be difficult for pre-service teachers to understand because they are abstract or complicated. Among these classes were "Molecular Biology, Invertebrate Zoology, and Genetics." Since these ideas are included in the senior high school curriculum, preservice teachers should be familiar with them. Pre-service teachers can effectively teach these ideas during their senior secondary school teaching practice activities if they have a good comprehension of them. However, a recent analysis that examined statistical data on students' performance in a Genetic course over a six-year period in a college of education, from 2017 to 2022, revealed a decline in the pass rate (Okanume, 2024).

However, the persistent drop in students' performance in biology may be attributed to the negative attitudes that students have developed as a result of the ineffective teaching methods that the majority of biology teachers use when teaching complex biological concepts. These methods fail to effectively engage students and aid in their understanding of basic concepts and principles (Nja et al., 2022; Etobro & Fabinu, 2017; Jean et al., 2021). According to Chinonso and Emenike (2019), a lack of comprehension of biological ideas, which is mostly a consequence of inefficient teaching methods, may frustrate students and result in a bad attitude and poor performance in the subject. Recent studies have shown that a teacher-centered approach to teaching may be a factor in students' poor achievement and persistently negative feelings toward biology. Nevertheless, Poor teaching methodology and inadequate laboratory equipment in biology can hinder students' understanding (Darling-Hammond, 2017) and application of biological concepts, leading to frustration and negative attitudes. Teachers often rely on charts, diagrams, and improvisation, limiting practical exercises (Ajemba et al., 2021; Ndayambaje et al., 2021). Another significant factor that may impact students' attitudes and biology performance is gender. Students may behave and perform differently depending on what the societal norms are for their gender. According to Tambaya and Matazu (2016), gender is a factor that has contributed to the stereotype that biology is a topic better studied by female students than by male ones. Because biology is perceived by male students as a feminine topic best suited for women, they have formed a negative attitude toward the subject (Ekineh & Adolphus, 2019; Makarova & Aeschlimann, 2019). However, implementing active teaching strategies that are appropriate for the subject matter and customized to the unique characteristics and learning styles of the students is necessary to address the low performance of pre-service teachers in biology and the negative attitudes of students toward the subject. Nalevska and Kuzmanovska (2020) research found that academic performance increased when the teaching approach was adjusted to the preferred learning styles of the students. Building on this, research has highlighted the use of active teaching pedagogies, which may support students' full participation, creativity, and teamwork (Mai et al., 2023; Chan and Zhan, 2019). It can also help to modify instruction from a teacher-centered to a student-centered approach, where students will take responsibility for their own learning

Recent literature has highlights the importance of active teaching pedagogies in fostering student engagement, creativity, and collaboration. Researchers have developed innovations like Brainbased teaching (Saleh and Subramaniam, 2018); Blended Learning Approach (Okoye et al., 2018; Obe and Taiwo, 2023; Ndirika, 2018),

and Gamification and Game-Based Learning (Michail et al., 2021; Gambari, 2019; Udeani & Akhigbe, 2020), to improve STEM education performance. However, there is limited attention on incorporating two active instructional pedagogies as a singular entity: (Gamified Flipped strategy), particularly in Genetic concepts of Biology. Gamification is employed in this context to enhance the flipped learning methodology.

In order to increase motivation and engagement, gamification, as an educational strategy, in this context refers to the integration of game-related components like points, stars, ladders, badges, and leaderboards inside a non-gaming setting. This approach seeks to increase or revitalize students' motivation, engagement, and sincere interest in the process of learning (Kapp, 2021; Aniekwe, 2018; Okanume, 2024). This method gives students the chance to actively engage in class activities and gives them incentives like points, stars, or badges in return. Additionally, as noted by Papadakis and Zaranis (2018), students may efficiently track and monitor their progress, including the accumulation of points and badges, through the use of a ranking board.

Gamification has several applications in the field of education. Teachers use gamification a lot to solve problems with student engagement and motivation (Oluwatayo, 2021). However since traditional teaching approaches sometimes find it difficult to hold students' attention, they become less effective and disengaged. But gamified components offer a structure that sparks interest, creates a feeling of achievement, and enhances a supportive learning environment. In accordance with this notion, Udeani and Akhigbe (2020) discovered in their study that gamification changes standard learning experiences into dynamic, interactive processes that increase students' enjoyment and engagement. Consequently, gamification capitalizes on people's innate drive for challenge and achievement by adding components like competition, advancement, and achievement (Dominguez et al., 2013; Landers et al., 2015). Furthermore, Gambari's (2019) study in Nigeria examined the effectiveness of a gamified instructional package on genetic concepts among secondary school students. The study, which involved 90 participants, found that gamified teaching improved students' attitudes and learning outcomes compared to standard lecture training. The findings suggest gamification as a potential educational strategy for biology teaching.

Additionally, Flipped learning is an instructional approach that reverses traditional classroom models by delivering content online or offline, often using pre-recorded videos or text. Students watch videos, read from text, and conduct research at home, prepared for active learning experiences like discussion, peer teaching, presentations, and group-based problem-solving under teacher guidance. The core objective is to shift instruction to learner-centered, with teacher-led instruction taking a backseat and active learning taking the forefront. Researchers have advocated for the adoption of novel instructional approaches in biology education to raise students' achievement and attitude in the subject. Several empirical investigations on these approaches have been carried out. However, flipped learning which involves students actively participating in activities, communicating with others, collaborating, and experiencing a stress-free classroom has been supported by studies. It has been discovered that this strategy raises achievement, particularly in biology. The main elements of flipped learning, according to Yilmaz and Baydas' (2017) research, are shifting the delivery of knowledge outside of the classroom and using class time for more advanced activities. However, they discovered in their research that the flipped learning approach not only greatly increased students' attitude and achievement but also encouraged participation and motivation. Park and Chae (2018) compared flipped classrooms with traditional classrooms, highlighting the active participation of students in flipped learning environments. They found that students in flipped learning environments performed better than those in traditional learning environments. A recent study by Riedl, Yeung, and Burke (2021) supported this claim by examining the effectiveness of a flipped active learning technique in a general biology course at a community college. After 15 weeks, 800 students participated in 33 sections of the course, and after 15 weeks, students in the active learning section outperformed their control group on common exam questions. Additionally, students from the active learning section received higher grades in subsequent biology courses. The study concluded that using a flipped active learning strategy improved students' performance and attitude in a general biology course at a community college.

Empirically, it is clear from a critical evaluation of flipped learning and gamification in the classroom that there are few research looking at how gamified flipped instruction affects genetic concepts. It is important to acknowledge that, despite the body of prior research, there is a relatively small number of studies that examine gender as a mediator between pre-service teachers' attitudes and achievement in a gamified flipped classroom.

Therefore, the main objective of this study is to provide insight into how gamified flipped instruction may affect pre-service teachers' attitude and academic performance regarding genetic concepts. Additionally, it examined the moderating effect of gender on pre-service teachers' attitudes and performance in genetics.

This study is based on Andrew Lander's (2015) gamification theory, which was adapted to explain the complex relationship that exists between gamification components and user behavior. Lander's theory suggests that adding game components to non-gaming contexts can improve learningrelated behaviors and attitudes, strengthening the link between instructional design qualities and learning outcomes. The study uses two accidental routes: moderation and mediation, which explain how gamification affects learning or encourages related behavior. The mediator pathway shows how gamification components directly affect user behavior or attitude, while the moderator pathway incorporates external variables such as system design, user characteristics, and instructional content. When well-integrated gaming components are added to educational content, moderation occurs, improving learning outcomes. Lander's goal is to supplement education rather than replace it, and the research uses Landers' gamified theory to understand the impact of gaming components on the attitude and academic performance of pre-service teachers in genetics.

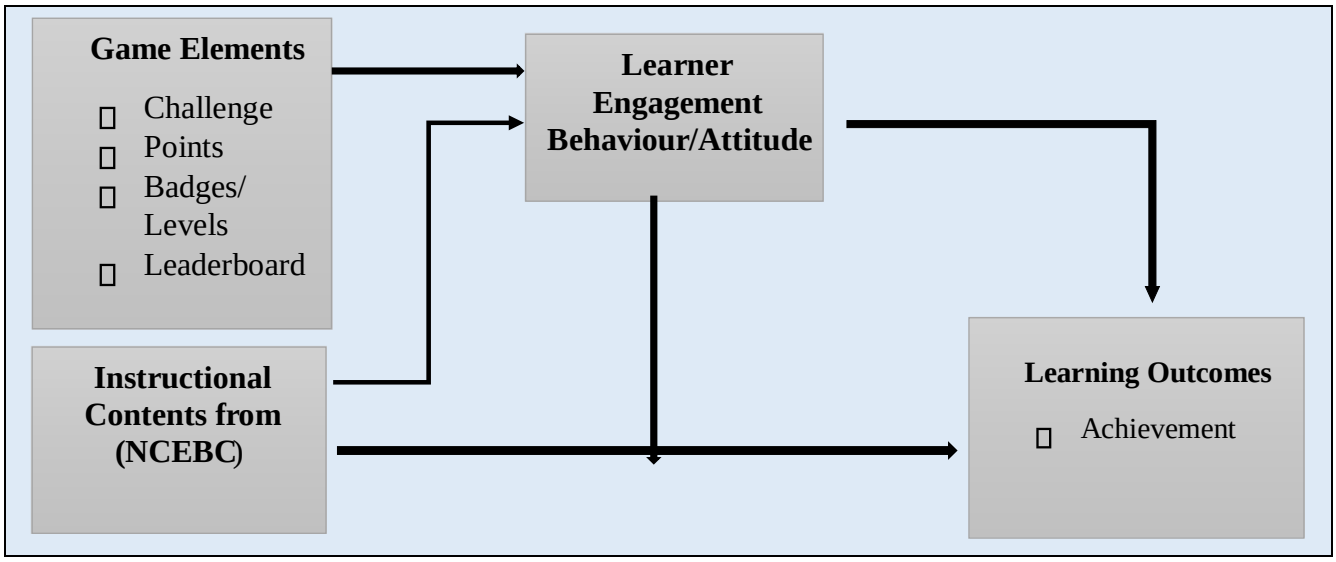

Figure 1. Gamified Learning Environment Adapted from Landers' (2015).

The conceptual framework of the study in figure 1 presents a hypothetical model which shows that the introduction of game attributes into instructional content drawn from the Nigerian College of Education Biology Curriculum (NCEBC) through Teacher Training College, Anambra State, will stimulate the students' learning behavior which will in turn, improve their learning outcomes (Achievement) and attitude towards learning Genetics.

Statement of Problems

The study of biology plays a vital role in a nation's scientific and technological advancement. To achieve this, it is crucial for students to have a strong grasp of biology concepts and develop a positive attitude towards the subject. However, there has been a noticeable setback due to students' negative attitudes towards biology. This has resulted to poor academic performance in both internal and external examinations. Gender differences have also influenced the effectiveness of instructional strategies employed by researchers to enhance students' attitude and academic performance in biology. This is because some students may lack full motivation and engagement in such pedagogical approaches. Although researchers have recommended incorporating active pedagogy, hands-on –activities, and interactive learning strategies such as gamification approach, use of blended learning approach, flipped learning approach, use of video- assisted learning and others, in order to enhance students' participation, attitude, motivation and performance and as well cultivates good use of time spent in biology classroom. However, there is a limited attention on the combination of two active instructional pedagogies such as gamification and flipped learning approach as a single instructional approach most especially in the field of biology particularly in genetic course.

Therefore, this study aims to explore the effect of Gamified Flipped learning strategy on the achievement and attitude towards Genetic concepts among pre-service teachers at Nsugbe, Anambra State. It also seeks to examine the moderating effect of gender on students' attitudes and achievement in biology.

Research Questions

The following research questions were answered in the study;

1. What is the effect of implementing the intervention on: (i) achievement (ii) attitudes towards pre-service teachers in biology?

2. Is there any difference in (i) achievement (ii) attitudes between male and female pre-service teachers after the intervention?

Hypotheses

The following null hypotheses are formulated to guide the study;

Ho1: There is no significant main effects of treatment on pre-service teachers': (i) achievement in (ii) attitudes towards in biology.

Ho2: There is no significant main effects of gender on pre-service teachers': (i) achievement in (ii) attitudes towards biology.

Ho3: There is no significant interaction effects of treatment and gender on pre-service teachers': (i) achievement in (ii) attitudes towards biology

METHODOLOGY

The study adopted a pretest-posttest control group quasi-experimental research design. The target population of this study comprised of all the one hundred and fifty (150) intact class of three hundred level (300 level) pre-service teachers offering Genetics (ZOO 301) at College of Education, Nsugbe. They were purposively selected on the criteria that: they were not yet preparing for external exercise such as teaching practice, and they were judged to be matured enough to effectively collaborate. The students were further randomly assigned to treatment and control group.

Instrument

Eight instruments were used for data collection, two response scales and four stimulus instruments. The instruments are: The Genetic Achievement Test (GAT), Questionnaire on Students Attitude to Biology (QSATB), Gamified Flipped Instructional Package (GFIP), Gamified Flipped Instructional Mode Guide (GFIMG), and Conventional Teaching Method Mode Guide (CTMMG). The stimulus instruments were Points, Levels, Stars and Scoreboard. Points were awarded to groups for successfully completing a given task each day during class time. Additionally, levels were awarded to most organized groups at the end of each class. The top-performing groups each week were recognized as "Star Groups" and awarded 5 stars as a means of motivation for all students to strive for excellence. Scores were recorded on a scoreboard to allow pupils to track their progress and improvement over time.

The Genetics Achievement Test (GAT) was a multiple choice self-constructed instrument used to measure the level of students' knowledge of selected Genetic concepts based on six levels of cognition according to Bloom's taxonomy of Cognitive Skills (Bloom 1956). The original 50 testitems were validated to 40 items after the instrument difficulty and discrimination indices were determined. The 40 test-items was trial-tested and the reliability was ascertained using KuderRichardson 20 which yielded a value of (r=0.79) which shows that the instrument is reliable enough for the study.

An Attitude Scale Questionnaire developed by Okanume (2024) was adapted for the study. The instrument was used to measure pupils' level of engagement, emotion or feelings, knowledge acquired and value they placed on Biology as a subject and Genetic as a course. The questionnaire comprises of twenty-six (26) items that requires pupils to tick from the four-likert type scale which were graded as: SA (Strongly Agree) 4, A (Agree) 3, D (Disagree) 2, and SD (Strongly Disagree). It consists of two sections. Section A contains the personal data of respondents' demographic information. While section B consists of 24 items on pupils' attitude towards BST. To ensure that the items in the instrument are consistently reliable, the questionnaire was administered to 30 biology students who were not part of the main study. Cronbach Alpha was used to analyse the data and a reliability coefficient of 0.96 was obtained which indicated that the instrument was consistently reliable.

The Genetic Instructional Package (GIP) validated by three experts from Educational Technology was developed using PowerPoint, Camtasia application (360), Google form for online quizzing. It contains multimedia elements like animated pictures, sounds (audio), and videos. In order to save cost on the side of the students, the package was sent to the students in experimental group using data saving application (Bluetooth and Xender) before and after each class time.

Method of Data Analysis

The data collected were analysed using Mean and Standard Deviation and inferential statistics of t-test, and two-ways analysis of covariance (ANCOVA) with the pre-test scores as covariates to test the hypotheses at 0.05 level of significance. Analysis of covariance was used to single out the initial group differences. Also, the Estimated Marginal Means (EMM) of the ANCOVA was used to detect the magnitude and direction of differences.

Procedure for Data Collection

The study was carried out in a College of Education, Anambra. Firstly, approval was sought from the Head of Department of Biology Education, and the lecturer in charge of the course (Genetics). They were brief on the purpose of the research in order to get correct responses without influence and bias in their opinion. The research ethics guiding the confidentiality of the respondents' data were highly maintained. The experiment lasted for 7 weeks with the help of two research assistants trained by the researchers. The procedure for data collection was done in phases using the chart below:

Pre-briefing and Hands-on training of Research Assistants and Students

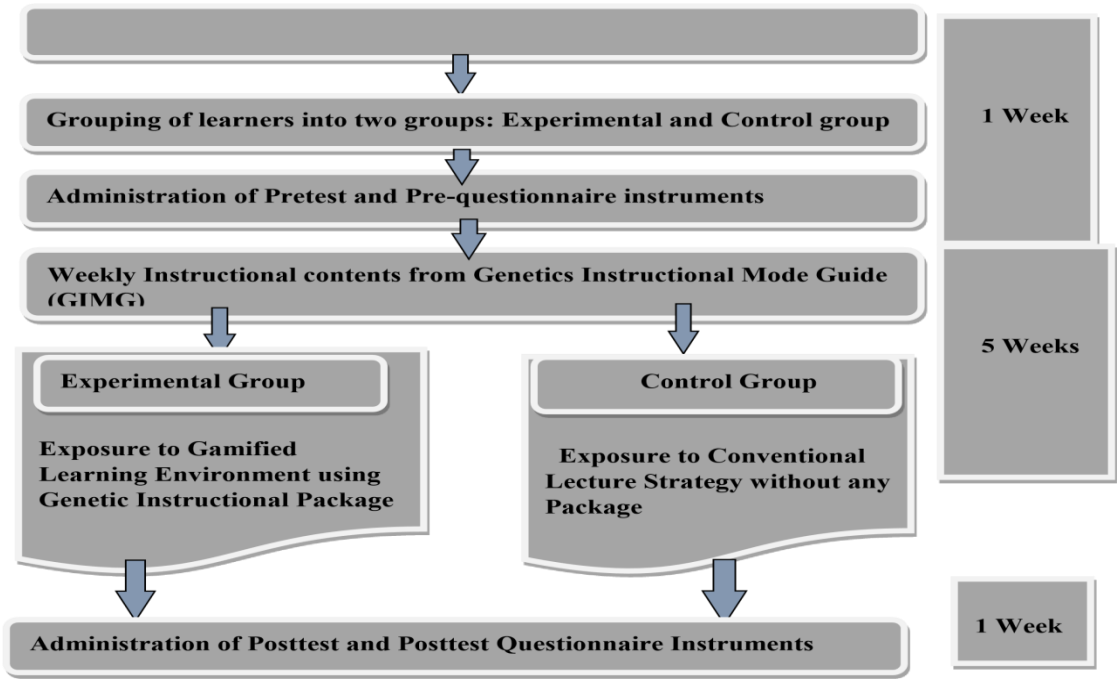

Figure 2: Phases for Data Collection Designed by the Researchers

RESULTS

Table 1: Descriptive Statistics of Respondent: Demographic information of students

Gender	Frequency	Percentage
Male	70	47%
Female	80	53%
Total	150	100%

Table 1, shows the frequency distribution of students who participated in the study based on gender. A total of 150 students participated. By gender; out of 150 respondents, 70(47%) were male and 80(53%) were female for both experimental group and control group.

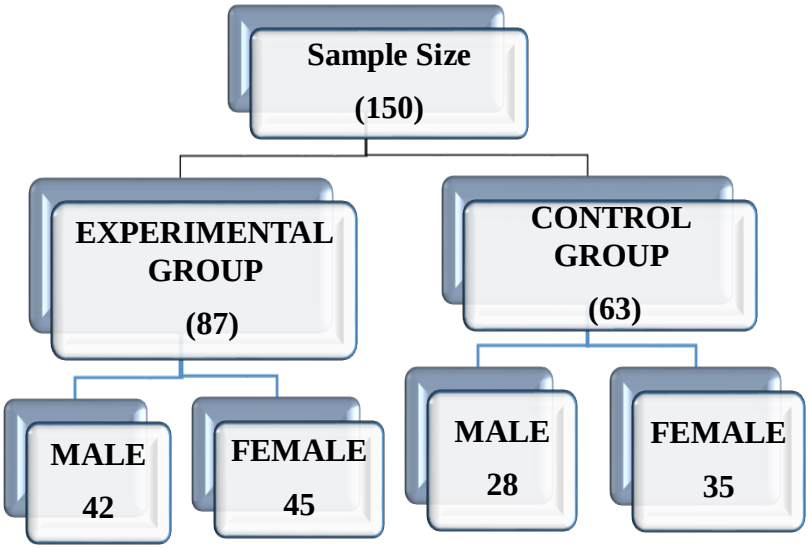

Figure 3: Demographic Distribution of Sample.

Research Questions

Research Question 1a: What is the effect of implementing the intervention on pre-service teachers' achievement in Biology?

This question was answered using mean and standard deviation, which were computed using the scores of pre-service teachers in the experimental group before and after the treatment. The results of the analysis are as presented in table 5.

Table 2: Mean on the performance before and after using Gamified Flipped learning

Mode of test	N	Mean	SD	Gained Mean
Post-test	87	73.33	9.05	30.78
Pre-test	87	42.55	8.64	

Results in table 2, show that the mean scores of pre-service teachers before and after exposing them to gamified flipped learning are 42.55 and 73.33 respectively. And it can be seen that the mean score of pre-service teachers after exposing them to flipped learning strategy increased, as the gained mean =30. 78. Thus, gamified flipped learning has positive effect on the pre-service teachers' achievement in Biology.

Research Question 1b: What is the effect of implementing the intervention on pre-service teachers' attitudes towards Biology?

This question was answered using mean and standard deviation, which were computed using the attitude mean scores of pre-service teachers in the experimental group before and after the treatment. The results of the analysis are as presented in table 6.

Table 3: Mean on the attitude before and after using Gamified Flipped learning

Mode of test	N	Mean	SD	Weighted Mean
Post-Attitude	87	3.54	0.446	1.20
Pre-Attitude	87	2.34	0.260	

Results in table 3, show that the attitude mean scores of pre-service teachers before and after exposing them to gamified flipped learning are 2.34 and 3.54 respectively. And it can be seen that the mean attitude score of pre-service teachers after exposing them to gamified flipped learning increased with the gained mean of 1.20. Thus, gamified flipped learning has positive effect on preservice teachers' attitude towards Biology.

Research Question 2: Is there any difference in the achievement of male and female preservice teachers after intervention?

Table 4: Achievement of male and female pre-service teachers after using Gamified Flipped learning

Gender	N	Mean	SD
Male	42	69.89	8.75
Female	45	67.27	8.64

Results in table 4 show that the achievement mean scores of male and female pre-service teachers after exposing them to gamified flipped learning are 69.89 and 67.27 respectively. And it can be seen that male pre-service teacher had higher achievement score than the females. There's a slight difference in their achievement.

Testing of Null Hypotheses

Hypothesis 1a: There is no significant main effect of treatment on pre-service teachers' achievement in Biology Table 5: Analysis of Covariance (ANCOVA) of Biology Achievement Test scores by Treatment, and Gender

Table 5 revealed that there is significant main effect of treatment on pre-service teachers' Biology

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	31341.143[a]	12	2611.762	47.704	0.000	.807
Intercept	24786.45	1	24786.454	452.72	0.000	.768
Pretest	43.071	1	43.071	.787	0.377	.006
Treatment	7986.168	1	7986.168	145.86	*0.000	.516
Treatment * Gender	70.637	1	70.637	1.290	0.258	.009

Error	7500.697	137	54.750			
Total	617676.000	150				
Corrected Total	38841.840	149				

R Squared = .807 (Adjusted R Squared = .790*) Denote significant difference at 0.05 level of sig

Achievement Test scores in ($F_{(1,137)}$ = 145.87; P< 0.05, partial η^2 = 0.52). The effect size is 52.0%. This indicates that 59.0% of the variation in pre-service teachers' achievement is as a result of the significant main effect of the treatment. Thus, hypothesis 1a was rejected. In order to determine the magnitude of the significant main effect across treatment groups, the estimated marginal means of the treatment groups was calculated and the result was presented in (Table 5.1).

Table 5.1: Estimated Marginal Means for Post-test by Treatment (Control and Experimental group)

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Control (Conventional Strategy)	47.377	1.163	45.078	49.676
Experimental (Gamified Flipped Learning)	68.311	1.177	65.984	70.639

Table 5.1 revealed that pre-service teachers in Experimental group (Gamified Flipped Learning) had the highest adjusted post-Biology Achievement Test mean score (68.31) while those in the Control group (Convention Strategy) had the least adjusted post- Biology Achievement Test mean scores (47.38).

Hypothesis 1b: There is no significant main effect of treatment on pre-service teachers' attitude towards Biology

Table 6.0: Analysis of covariance of Post-Attitude to Biology by Treatment and Gender

Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	14.458[a]	12	1.205	7.858	0.000	.408
Intercept	39.926	1	39.926	260.38	0.000	.655
Pre-Attitude Main effects	.391	1	.391	2.547	0.113	.018
Treatment	8.526	1	8.526	55.601	*0.000	.289
Gender 2-way interaction	.002	1	.002	.011	0.916	.000
Treatment * Gender	.374	1	.374	2.442	0.120	.018
Error	21.007	137	.153			
Total	1655.135	150				
Corrected Total	35.465	149				

R Squared = .408 (Adjusted R Squared = .356) * Denote significant difference at 0.05 level of sig.

Table 6.0 shows that there is significant main effect of treatment on pre-service teachers' attitude in ($F(1,137) = 55.60$; $p < 0.05$, partial $\eta^2 = 0.29$). The effect size is 29%. This indicates that 29% of the variation in pre-service teachers' attitude score is as a result of the significant main effect of the treatment. Thus, hypothesis 1b was rejected. Therefore, there is significant main effect of treatment on pre-service teachers' attitude towards Biology. In order to determine the magnitude of the significant main effect across treatment groups, the estimated marginal means of the treatment groups was calculated and the result was presented in Table 6.1.

Table 6.1: Estimated Marginal Means for Post-Attitude by Treatment (Control and Experimental groups)

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Control (Conventional Strategy)	2.944	.057	2.831	3.057
Experimental (Gamified Flipped Learning)	3.542	.060	3.443	3.681

Table 6.1 revealed that pre-service teachers in Experimental group (Gamified Flipped Learning) had the highest adjusted post-Attitude mean score (3.56) while the Control group (Convention Strategy) had the least adjusted post- Attitude mean scores (2.94).

Hypothesis 2a: There is no significant main effect of gender (male and female) on pre-service teachers' achievement in Biology

Table 5.0 shows that there is no significant main effect of gender on pre-service teachers' Biology Achievement Test Scores ($F_{(1;\ 137)} = 0.39$, $p > .05$, partial $\eta^2 = 0.003$). Thus, hypothesis 2a was accepted.

Hypothesis 2b: There is no significant main effect of gender (male and female) on pre-service teachers' attitude towards Biology

Table 6.0 shows that there is no significant main effect of gender on pre-service teachers' attitude towards Biology ($F_{(1;\ 137)} = 0.01$, $p > .05$, partial $\eta^2 = 0.00$). Thus, hypothesis 2b was accepted.

Hypothesis 4a: There is no significant interaction effect of treatment and gender on preservice teachers' achievement in Biology

Table 5.0, shows that there is no significant interaction effect of treatment and gender on preservice teachers' Biology Achievement Test Scores ($F_{(1;\ 137)} = 1.29$, $p > .05$, partial $\eta^2 = 0.009$). Thus, hypothesis 4a was not rejected.

Hypothesis 4b: There is no significant interaction effect of treatment and gender on preservice teachers' attitude towards Biology

Table 6.0, shows that there is no significant interaction effect of treatment and gender on preservice teachers' attitude towards Biology ($F_{(1;\ 137)} = 2.44$, $p > .05$, partial $\eta^2 = 0.02$). Thus, hypothesis 4b was not rejected.

Discussion Effect of Treatment on pre-service teachers' achievement in Biology

The findings of the study revealed significant differences in the achievement scores of pre-service teachers in the experimental and control group. Pre-service teachers exposed to Gamified flipped learning had higher achievement scores than those in the control group. The findings showed that the instructional strategy (Gamified flipped learning) is more effective than the conventional teaching strategy in improving pre-service teachers' achievement in Biology. However, this high achievement of students in the experimental group could be as a result of incentives that were given to students individually and in groups, inform of rewards such as points, stars, and levels, which motivates the students to perform better. Moreover, students were given study materials (scaffolding) such as: video lesson and printed text to study on their own learning pace ahead of class

time. . Nevertheless, when learning environment is fun, engaging friendly, and competitive students' level of enthusiastic tends to increase leading to high performance in their classwork. This greatly helped them attain their level of proximal development at the end of the treatment process. The result is in support of the findings of (Gunduz and Akkoyunlu. 2020; Zainuddin et al., 2019; Giannakos & Jaccheri, 2017). Their study confirmed that integrating gamification concepts into the flipped classroom improves students' academic achievement in Biology. Their findings also revealed that participants in the gamified flipped classroom showed high levels of motivation because their needs for competence, autonomy, and relatedness were satisfied. This is as a result of integrating gamification concepts into the flipped classroom, such as adding challenges, incentives, points, and rewards to quiz questions, which created a more engaging, enjoyable learning experience, increases students' participation, and promotes deeper and more meaningful learning for students. It also allows learners to effectively monitor and track their progress including accumulated points and acquired badges through the utilization of a ranking board (Papadakis and Zaranis, 2018). All these have a positive effect on the academic achievement of students especially in learning Genetics concepts in biology.

Therefore, we can conclude that using gamified flipped learning strategy can improve the academic achievements of pre-service teachers in Biology. **Effect of Treatment on pre-service teachers' attitude in Biology**

The significant differences in the attitude of pre-service teachers in the experimental and control group was revealed in the findings of the study. Pre-service teachers in the experimental (gamified flipped learning) group particularly had the highest adjusted post attitude mean score while those in the control group had the least adjusted post-attitude mean score. This result is in line with the findings of (Dorji and Dorji (2022). After their experiment, their study found that the students taught with the flipped learning approach performed better and had more positive attitudes compared to those taught with conventional methods. Since flipped learning approach changes the order of classroom activities by delivering instruction outside of class, it creates room for more interactive and in-depth learning during class time. Other studies by Polar (2014) and Gibson et al. (2015) also highlighted the positive influence of games on learners' attitudes and success, as games have always captivated the attention of many people (Sari & Altun, 2016). Additionally, using Gamification to complement the flipped instructional pedagogy for pre-service teachers enhance motivation, engagement, and performance and as well to cultivate a positive attitude towards the subject. It is worth noting that pre-service teachers who undergo this Gamified Flipped instructional approach developed a strong intention or inclination towards utilizing similar technology in their future teaching endeavors.

Effect of Gender on pre-service teachers' achievement and attitude towards Biology

The study found that gender does not have a significant effect on the achievement and attitude of pre-service teachers. This findings is in consonance with the findings of (Tugba et al., 2018; Godpower-Echie & Ihenko, 2017; Oluwatayo, 2021) which revealed that gender had no significant influence on the achievement of students in science subjects, as students of different genders were found to have performed well. Nevertheless, they emphasized that female students do not have the tendency to outperforming the male students in the class, and male students do not have the tendency of outperforming their female counterpart. Hence, Some studies showed that male students see biology as feminine subject and well suited for females, and as a result, have developed negative attitude in biology subject (Ekineh &Adolphus, 2019), and have had poor performances in the subject when compared to their female counterparts (Makarova & Aeschlimann, 2019). Furthermore, the studies of (Tamarin et al., 2022; Seaborn & Del 2015) posited that women exhibit greater interest in gamification and demonstrate heightened engagement in digital environments relative to males. However, this study proves that using interactive and engaging instructional strategy such as gamified flipped learning can bridge the performance gap and attitude gap between both genders. **Conclusion** Since biology plays a crucial role in a nation's scientific and technological advancement, it is imperative to incorporate active and engaging instructional strategies that will not only improve academic achievement but also foster creativity, critical thinking, and collaboration and enhance effective communication skills among students in this 21st century. This study demonstrated that using a gamified flipped instructional strategy effectively enhances the academic achievement of pre-service teachers in biology. Educators can promote positive attitudes, engagement, motivation, collaboration, critical thinking and overall learning outcomes by incorporating active and handson teaching methods. Additionally, the study revealed that gender does not impact the achievement of pre-service

teachers in biology when utilising an active instructional approach. Both male and female students performed equally well in a gamified flipped learning environment, as they became immersed in the game-like activities, faced challenges and experienced improved behaviour and learning outcomes.

RECOMMENDATIONS

Based on the findings, this study recommends the following:

1. Biology educators should adopt the use of gamified flipped instructional approach especially, while teaching genetic concepts because it has been proven to be effective in fostering collaboration, engagement, critical thinking and creativity among pre-service teachers.

2. Government and professional bodies such as STAN, NTI and NUT etc., should expose biology teachers to new and active pedagogies which would help to foster creativity, collaboration and effective communication skills among students.

3. Curriculum planners should use information provided in this research as a guide in subsequent planning of biology curriculum.

Therefore in consideration of the above findings, the study focused on a particular college of education, there would be need for future studies to extend the scope of this research to two or more colleges of education.

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