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Effect of simulation-aided flipped classroom model on secondary school students' interest and achievement in genetics

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Abstract

The study was on effect of simulation aided flipped classroom model on secondary school students' interest and achievement genetics in Anambra State. Six research questions and six hypotheses tested at 0.05 level of significance guided the study. A quasi experimental design, specifically the non - equivalent group design was adopted for the study. The population of the study consisted of 13, 596 SS3 Biology students that registered for the 2023/2024 academic session in the Anambra State post primary schools. A total of 300 Biology students formed the respondents of the study. A researcher made Biology achievement test and an interest scale structured and validated at a reliability coefficient of 0.92 and 0.85 respectively served as both achievement and interest instrument. Meanwhile, mean and standard deviation was used to answer research questions while ANCOVA was used to test the hypotheses. The study revealed that simulation aided flipped classroom was significant in improving secondary school students' interest and achievement in biology. Among others, the study recommended a swift implementation of the simulation flipped classroom in teaching and learning of genetics. By implication, the study contributed that biology students learn more outside the classroom. Hence, such knowledge gained outside the classroom becomes basis of the new experience and can be extended to real life situations particularly in problem solving.

Keywords:

Effect, Simulation, Aided-Flipped, Classroom Model, Interest, Achievement, Genetics.

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INTRODUCTION

Background to the Study

Science and technology are appreciated globally as the backbone of both the economic growth of countries and the urgent need for a scientifically literate population. Science is a critical enterprise upon which nations rely to advance technologically. Science education is recognized as an essential tool for economic and technological development, promoting self-reliance and self-sufficiency. It serves as both a platform and a process that cultivates citizens who are creative, critical, analytical, and rational (Ojo& Smith, 2021).

Biology, as a natural science, focuses on the living world; it explores the structure, functions, development, and interactions of living organisms with one another and their environment. Uche (2022) highlighted the importance of biology, which includes helping individuals comprehend their bodily functions, questioning superstitions through a better understanding of causality, appreciating life, emphasizing the importance of good health, guiding career choices, and instilling scientific skills and attitudes necessary for addressing personal and societal problems (Nwosu&Chukwu, 2023).

Genetics, which is the focus of this study, is the branch of biological science that examines the mechanisms of heredity. It is scientifically concerned with the study of heredity and variation in living organisms (Oluwaseun, 2021). Introduced into the school certificate biology syllabus in the mid-1970s, genetics covers aspects such as variations, mitosis and meiosis, monohybrid crossings, sex determination, co-dominance, and mutation. Previous studies indicate that genetics is often perceived as a challenging topic by both students and teachers (Adebayo, 2022). This field focuses on establishing a scientific basis for understanding how traits are transferred from parents to their offspring across generations.

However, many students manage to pass external examinations through examination malpractice, aided by the proliferation of special centers across the country. Conversely, their failure in internal examinations indicates a lack of understanding of key concepts.

Reports from the Chief Examiners of WAEC (2017-2023) also highlighted poor performance in several biology concepts, including genetics. This underachievement has been attributed to weaknesses such as inadequate conceptual understanding, lack of mastery, and insufficient critical thinking abilities among students (Eze, 2023). Consequently, students' inability to demonstrate mastery and conceptual understanding in genetics adversely affects their overall achievement in the subject.

Achievement can be defined as any effort that is significant and valuable to a particular program, albeit often difficult, and is successfully undertaken through knowledge, skills, and experience. According to Ibrahim (2020), achievement refers to accomplishments attained through exertion, skills, practice, and perseverance. The success of any teaching and learning process, which invariably influences students' academic achievement, depends on the effectiveness and efficiency of the teachers. However, the poor achievement in biology,

as noted by Chukwuma (2021), is often attributed to conventional teaching methods and students' lack of interest in abstract and complex concepts.

Interest is a crucial variable in learning because when students are interested in an activity, they are likely to perform better. Interest can be described as the feeling of attraction or aversion towards an activity, influencing choices or preferences for specific types of activities over others (Adeleke, 2021). It serves as a motivating force that facilitates learning (Ifeanacho&Okoye, 2022). Interest can also be understood as a student's willingness to engage with a learning activity to varying degrees (Chukwuma, 2021). Studies on interest in biology, such as those by Okeke (2021) and Aforka (2022), emphasize the importance of fostering interest in biology education.

Research indicates that the type of interest a student brings to the classroom significantly impacts their ability to demonstrate conceptual understanding and achieve meaningful learning outcomes. If a student has a positive interest in a particular subject, they are more likely to enjoy studying it and derive satisfaction from their knowledge, which can greatly enhance their academic achievement. Teachers employ a range of methods aimed at facilitating meaningful learning in biology. These methods include lecture, demonstration, discovery, project-based learning, and inquiry-based approaches, among others. The lecture method is the most commonly used, primarily because it allows teachers to cover extensive content efficiently and ensures that all students receive the same information simultaneously (Nwankwo, 2020).

Recent studies have shown that the lecture method is insufficient for imparting the relevant knowledge and skills necessary for biology students to excel and respond effectively to societal challenges (Adeyemi, 2022; Ojo&Nwosu, 2021). The lack of engagement inherent in this method limits students' ability to develop critical thinking and problem-solving skills essential for their academic success. Biology teachers should adopt innovative teaching methods that enhance students' understanding of the concepts, topics, or principles being taught. Some of these innovative teaching methods include Think-Pair-Share instructional strategy, collaborative learning, inquiry-based teaching, and simulation-aided flipped classroom methods.

The flipped classroom instructional practice is a modern model for effective teaching. According to Adebayo and Eze (2020), flipped classrooms involve students gaining initial exposure to learning content outside the classroom, typically through reading or lecture videos, and then utilizing class time to engage in problem-solving, discussions, or debates. The flipped classroom represents a form of blended learning where learners access content online—listening to audio lectures or watching video lectures—often from home, while assignments and collaborative tasks are completed in class with teacher guidance (Ifeanacho & Okoye, 2021; Nwankwo&Ugwu, 2022). This approach allows students to work together, exchange opinions and experiences, and discuss strategies and outcomes, thereby fostering a collaborative learning environment. In a flipped classroom, the teacher's role transitions to that of a mentor or facilitator in the learning process.

It is not surprising that the flipped classroom method has garnered considerable support over the years, attracting the attention of numerous researchers. For instance, Marlowe (2019) investigated the impact of the flipped classroom on student achievement and found that students exhibited positive attitudes towards the method, appreciating the ability to choose assignments and explore topics of personal interest in greater depth.

Another intriguing aspect of modern education is the integration of computer simulations. Mchaney (2021) defines computer simulation as the use of a computer to imitate the operations of real-world processes or facilities, modeled using logical, statistical, or mathematical relationships. The incorporation of simulation-aided instruction not only enriches the learning experience but also provides dynamic opportunities for students to engage with complex biological concepts. By utilizing simulation-aided instruction strategies, we can vividly present different phenomena and processes, simulate complex content, and convey various levels of abstraction. This approach supports meaningful and authentic learning experiences. Employing suitable technologies, such as simulations, can ignite students' enthusiasm for their own learning and foster more active involvement in the teaching and learning process. According to Olufemi (2021), simulations are a direct approach to achieving deep learning objectives by fostering not only collaboration but also critical thinking and problem-solving skills. Simulation-aided instruction enables learners to comprehend complex concepts, stimulate their interest, and apply their understanding of relevant concepts to real-life problems..

Appropriately implementing simulation-aided flipped instruction may enhance learners' academic performance, broaden their horizons, increase motivation, and make biology instruction more engaging. Research has shown that computer tools significantly improve learning outcomes through simulations in science education (Nwankwo & Ogunyemi, 2022; Bello, 2023).Instruction strategies that incorporate technology allow us to present different phenomena and processes vividly, simulate complex content, and present various levels of abstraction. This helps in meaningful and authentic learning. Applying suitable technology like simulation-aided instruction may help get students excited about their own learning and become more actively involved in the teaching and learning process. In order for active learning to occur, Akinsola (2019) suggested that instructors should: a) focus on outcomes rather than technique, b) ensure that learning is experiential, and c) demand active participation by students. These suggestions may not achieve the desirable outcome using conventional teaching strategies. Therefore, a combination of instructional strategies might come to the rescue. Simulation-aided flipped classroom might be a remedy. The adoption of technologies such as animation, simulation, interactive computer programs, and others in the educational enterprise during instruction increases learners' perspectives and achievement (Ahmadu, 2019).

Nevertheless, we cannot completely exclude the influence of gender on achievement. Recent studies indicate that there is, in fact, a significant influence of gender in the learning process, especially regarding biology. Further, there have been inconsistent findings on the influence of gender on students' academic achievement in biology. Gender is a societal construct assigned to both sexes by different cultures based on the roles played by both men

and women. Tolland and Evans (2019) view gender as a social construction relating to behaviors and attributes based on levels of muscularity and femininity. Some of the aforementioned studies include Akinwunmi (2019), whose report revealed no clear difference in cognitive, affective, and psychomotor skills of learners with respect to gender. Conversely, Ogunleye (2021) claimed that gender has a significant influence on students' conceptual understanding in favor of female students. Results from many researchers on the influence of gender on the academic achievement of students are inconclusive.

The inconsistencies in these results have become a source of concern for the researcher.. This unfortunate scenario has led to what some scholars called the 'gender digital divide'. The gender digital divide is seen in the underachievement of students in Biology. Also, Tella and Mutula in Abdulahi (2023) stated that the concern of gender disparity in the use of ICTs calls for concern and have continued to be a relevant subject of debate not only in developing economies but the developed ones. Hence an attempt will be made to find out whether the simulation-aided flipped classroom will constrict the gap in achievement and interest in biology irrespective of gender.

Statement of the Problem

Genetics is a major biology content of socioeconomic importance. Introduced in the school certificate biology syllabus in the mid-1970s, genetics covers core areas of social, agricultural, and medical concerns including heredity, variation, hybrids, sex determination, co-dominance, and mutation, among others. However, despite its relevance and judging by the abundance of empirical evidence on the achievement gap, genetics has continued to feature as one of the most difficult biology topics. Evidence from WAEC Chief Examiner's reports, among others, revealed that students' inability to demonstrate conceptual understanding and mastery of genetics has continued to cost them significant scores in examinations. It follows that students' inability to achieve meaningfully in genetics affects their overall achievement in biology examinations. In ameliorating achievement gap in genetics, researchers have come to deemphasize the persistent use of the traditional lecture method of instruction by biology teachers. They opined that although the traditional lecture method of instruction encourages larger content coverage among others, it have failed to enhance conceptual understanding and mastery which are basis for achievement optimization in genetics. Hence, they advocated for a shift to some novel strategies believed to be learner centered and which will help optimize achievement through proactive learner engagement. However, despite these novel methods, achievement in genetic is yet to improve. Perhaps, these methods concerns more on improving achievement through some hands on mind on activities with no consideration that considerable learning occurs outside the classroom, where it is initiated and structured by students. Students' ability to initiate and structure learning outside the formal classroom and ahead of the real experience being a distinctiveness of the simulated aided flipped classroom may result in greater control over tasks. Hence, enhancing their interest in the task and by extension improve their achievement in such area. Perhaps, by providing that biology students initiate and structure their learning of genetics outside the formal classroom and ahead of the real experience as obtained in simulated flipped classroom, their interest in genetics may be enhanced and by extension improve their

achievement. It is on this assertion that the current study seeks to investigate what outcome biology students' will obtain in genetics when exposed to the simulated aided flipped classroom. Therefore, the problem of the current study put in question form: what is the effect of simulation aided-flipped classroom on secondary school students' achievement and interest in genetics?

Purpose of the study

The purpose of this study was to investigate the effect of simulation aided-flipped classroom on secondary school students' academic achievement and interest in Genetics. Specifically, the study sought to investigate the:

1) Mean achievement scores of students taught genetics using simulation aided-flipped classroom and those taught using traditional lecture method.
2) Mean interest scores of students taught genetics using simulation aided-flipped classroom and those taught using traditional lecture method.
3) Mean achievement scores of male and female students taught genetics using simulation aided-flipped classroom.
4) Mean interest scores of male and female students taught genetics using simulation aided-flipped classroom.
5) Interaction effect of simulation aided-flipped classroom and gender on mean achievement scores of students' in genetics.
6) Interaction effect of simulation aided-flipped classroom and gender on mean interest scores of students' in genetics.

Research Questions

The following research questions were posed to guide the study.

1) What is the mean achievement scores of students' taught genetics using simulation aided flipped classroom?
2) What is the mean interest scores of students' taught genetics using simulation aided-flipped classroom?
3) What is the mean achievement scores of male and female students' taught genetics using simulation aided-flipped classroom?
4) What is the mean interest scores of male and female students' taught genetics using simulation aided-flipped classroom?
5) What is the interaction effect of teaching methods and gender on students' mean achievement in genetics?
6) What is the interaction effect of teaching methods and gender on students' mean interest in genetics?

Hypotheses

The following null hypotheses were formulated and tested at.05 alpha level to guide the study:

Ho_1: There is no significant difference in the mean achievement scores of students taught genetics using simulation aided-flipped classroom.
Ho_2: There is no significant difference in the mean interest scores of students taught genetics using simulation aided-flipped classroom.
Ho_3: There is no significant difference in the mean achievement scores of male and female students taught genetics using simulation aided-flipped classroom.
Ho_4: There is no significant difference in the mean interest scores of male and female students taught genetics using simulation aided-flipped classroom.
Ho_5: There is no significant interaction effect between teaching methods and gender on students' achievement in genetics.
Ho_6: There is no significant interaction effect of teaching methods and gender on students' interest in genetics.

METHOD

The design of the study was quasi-experimental research design. Pretest, post test, non- equivalent, control group was adopted. The choice of the design is justified because the respondents are pre-tested and the randomization of respondents was not possible. Hence, reflecting the submission of Nworgu (2015),

$E \rightarrow O_1 \rightarrow \quad X_1 \rightarrow O_2$
……
$C \rightarrow O_1 \rightarrow \quad X_2 \rightarrow O_2$

Where:
E = Experimental Group,
C= Control Group,
O_1 = Pretest,
O_2 = Posttest,
X_1= Treatment,
X_2 = Control variable or placebo.

The study was conducted in Anambra State, Nigeria. Anambra is one of the 36 states that made up the Federal Republic of Nigeria and is situated at the Southern-Eastern part of the country. It is bounded at the East, West, North and South by Enugu, Delta, Kogi and Imo states respectively. It is a core Igbo state predominated by economic conscious citizens such as farmers, scholars, traders, civil servants etc. Anambra state is made up of 21 Local Government Areas which are politically grouped into three senatorial districts with each of the senatorial districts housing two education zones each, thereby giving rise to the six education zones to include: Aguata, Awka, Nnewi, Onitsha, Ogidi, and Otuocha education zones. Anambra state houses a total of 267 public secondary schools, 161 coeducation

schools, 45 boys schools, 61 girls schools and numerous private secondary schools (Post Primary Secondary School Service Commission, 2023).The choice of Anambra State is justified by its status as a key educational hub with a diverse student population and a commitment to innovative teaching methods. The state's focus on enhancing science education, especially in genetics, aligns with the need to boost student engagement and achievement through modern pedagogical approaches such as simulation-aided flipped classroom. Researchers' choice of choosing Anambra state was justified because of their diverse educational system with various school and institution that provide rich contest for studying teaching methods, learning outcomes, or educational interventions. The population of the study was13, 596 SS3 biology students' (7, 283 females and 6, 313 males) registered in the 267 public secondary schools across the six education zones in Anambra state (Post Primary School Service Commission Awka, 2023). This as obtained was the actual number of SS3 biology students that registered for the 2022/2023 academic session in public secondary schools of Anambra state. 300 SS3 biology students participated in the study. Stratified random sampling method was used to stratify the education zones into different strata (Strata A: Ogidi and Otuocha, Strata B:Awka, Onitsha, Strata C: Nnewi and Aguata) that made up Anambra state. The education zones were arranged based on the strata. One education zone was chosen, the next was jumped sequentially till three were successfully sampled to represent the whole. Out of the six zones three education zones were drawn to include: Ogidi, Awka and Nnewi education zones. Justification for the stratified method was to ensure that closely related education zones which may share common characteristics were not selected. Of the three education zones, Awka has five Local Government Areas (Anaocha, Awka North, Awka South, Dunukofia and Njikoka) with a total of 54 public secondary schools (30 coeducational, 5 boys and 9 girls schools). Nnewi has four Local Government Areas (Ekwusigo, Nnewi North, Nnewi South and Ihiala) with a total of 44 public secondary schools (27 coeducational, 7 boys and 10 girls schools). Ogidi has three Local Government Areas (Idemmili North, Idemmili South and Oyi) with a total of 30 public secondary schools (20 coeducational, 4 boys and 6 girls schools). From the sampled zones, lucky deep was used to select one local government each from where two schools that satisfied major criteria of the study (such as adequate and functional biology laboratory, equipped computer facilities, power supply, qualified biology teachers as well as reliable lesson timetable among others) was purposively sampled to participate in the study. Out of the sampled schools, four has double streams of about 22 to 34 students per class while the remaining two has single classes each of between 30 to 35 students per class summing to sis classes of 300 students to participate in the study. Also, lucky deep method was used to assign schools into experimental and control groups respectively. Justification for the lucky deep was to ensure that each of the sampled schools stands a chance of being selected for either experimental or control group. The researcher's choice of class of respondents was justified because; the subject content adopted by the study was covered by their class curriculum. Also, the choice of coeducational schools was attributed to gender as a moderating variable to the study. The instruments were: "Genetics Achievement Test (GAT)" and Genetics Interest Scale (GIS). The Genetics achievement test was based on SS3 Biology curriculum for senior secondary schools. It consisted of fifty (50) multiple- choice test items with options A-D, which was developed by the researcher using a test blue print. The GAT

was divided into two sections A and B. Section A provides respondents' demography while section B contains 50 multiple-choice test items that was used to measure the achievement of the students in Genetics. The GAT instrument items was drawn from the senior secondary three Genetics content and was converted to 100% each items bearing two mark, that is to say that the objectives of each sub-topic guided the researcher in the coverage of the GAT items. The Genetic Interest Scale (GIS) consist of sections A and B. Section A consisted of respondents' demography while section B consisted of 20 items structured on a four-point scale of Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD) which was used to ascertain the level of interest of students in Genetics. The respondents were expected to indicate their degree of agreement or disagreement on interest in Genetics by a tick (√) in the appropriate column. The responses of strongly agree, agree, disagree and strongly disagree were respectively assigned value points of (4, 3, 2, 1) and the reverse (1, 2, 3, 4) for negative response. The total raw scores of the students' responses to the items was used to ascertain their level of interest in Genetics. All the research questions were answered using mean and standard deviation while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. The choice of ANCOVA is because of the nature of the design of the study i.e. Quasi experimental (specifically non-equivalent control-group design). This is because the design permits the use of pre-test, which acts as covariate, therefore, ANCOVA helps to establish the homogeneity or equivalence of the two groups before treatment. Besides this, since intact classes were used for the study, ANCOVA also helps to increase the power of the test because of type 1 error that may occur because of non-randomization of the subject of the study.

Discussion of Results

The Effect of SAFC on Students Achievement in genetics

The result presented in Table 1 shows that the students exposed to Simulation Aided Flipped Classroom had a pretest mean achievement score of 42.95 with a standard deviation of 95.87 and a posttest mean achievement score of 70.72 with a standard deviation of 4.46. The difference between the pre achievement and post achievement mean score for the experimental group was 27.77. On the other hand, students exposed to traditional lecture method had a pretest mean achievement score of 24.12 with a standard deviation of 4.50 and a post test mean achievement score of 37.24 with a standard deviation of 5.96. The difference between the pre test achievement and post test mean achievement scores for control group was 13.12.

Albeit, for each of the groups, the post test mean were greater than the pre test mean with the group taught genetics using simulation aided flipped classroom method having a higher mean gain. This indicated that Simulation Aided Flipped Classroom method had more effect on students' achievement in genetics than the Traditional Lecture Method. The above finding is further confirmed by data in Table 7 whose result showed that Simulation Aided Flipped Classroom has significant effect on students' achievement in genetics. With an F-ratio of 485.977, significant p-value at 0.000 level, which is less than the set 0.05 significant level, the null hypothesis was rejected. The study concluded that there was a significant

difference in the mean achievement scores of students taught genetics using Simulation Aided Flipped Classroom and those taught using traditional lecture method.

Therefore, the findings of this study is in line with the views of Okeh (2020) as well as Thomas (2020) on simulation aided flipped classroom. Also, the findings agreed with the work of Gerald (2021) who reported that the mean achievement score of mathematics students taught algebra using traditional lecture method were slightly lower when compared with those thought algebra using the simulation aided flipped classroom. Also, the findings of the current study aligns with the works of Atwa, Din and Hussin (2020) who upheld that Simulation Aided Flipped Classroom leads to greater students achievement in physics as it permits for enhancement of achievement in physics. In addition, the findings of this research is in consonance with the work of Asuksoy and Sorakin (2021) who revealed that clicker aided flipped classroom model was significantly positive on the achievement of secondary school students in physics. Similarly, the works of Williams and Ogun (2022) as well as Clark (2022) which respectively opined that simulation flipped classroom is a learning strategy that thrives well with many indigenous "ways of knowing" gave credence to the finding of this study.

Students' active participation in biology learning process under SAFC accounts for the superiority of the strategy over traditional lecture method.

The Effect of SAFC on Students' Interest in Genetics

The result presented in Table 2 shows that the students exposed to simulation aided flipped classroom had a pretest mean interest score of 13.32 with a standard deviation of 3.57 and a posttest mean interest score of 49.81 with a standard deviation of 7.51. The difference between the pretest and posttest mean interest scores was 36.49. The students exposed to traditional lecture method had a pretest mean interest score of 9.66 with a standard deviation of 7.62 and a post test mean interest score of 17.53 with a standard deviation of 3.85. The difference between the pre test and post test mean interest scores for control group was 7.87.

Although, for each of the groups, the post interest meant scores was greater than the pretest interest mean scores with the group taught genetics using simulation aided flipped classroom method having a higher mean gain. This indicated that simulation aided flipped classroom method had more effect on students interest in genetics than the traditional lecture method.

The above finding is further confirmed by data in Table 8 whose result showed that simulation aided flipped classroom has significant effect on students' interest in biology. With an F-ratio of 2025.217, significant value at 0.000 level, which is less than 0.05 significant level, the null hypothesis was rejected. Thus, the study concluded that there was a significant difference in the mean interest scores of students taught genetics using SAFC and those taught using traditional lecture method.

This finding therefore is consistent with the view of Stayer (2019) that students' interest could be enhanced through interactions and opportunities inherent in simulation aided

flipped classroom. The findings also aligns with the submissions of James (2020), Cagande and Jugar, (2021) that students' interest in biology is aroused and sustained when they are properly simulated, engaged and their view sort for in teaching and learning. This showed that an instructional strategy should be able to motivate students to develop interest in biology by intimating them early enough while providing for interaction with cognitive tools and social environment, which in turn will boost and develop confidence in the students. In addition, the works of Lia and Hwang (2023) vindicated the findings of the current study. They opined that the act of pre-class intimacy inherent in the simulation aided flipped classroom often results in the commendable level of curiosity necessary to initiate interest in the content.

It therefore followed that with a simulation aided flipped classroom, learners are subjected to series of pre-class activities that aid the development of interest through series of interactions, activities and encounter. This explains the overall higher mean interest score of students exposed to SAFC over those exposed to lecture method.

The Effect of SAFC on Male and Female Students Achievement in Genetics

The result presented in Table 3 shows that the male students exposed to simulation aided flipped classroom had a pretest mean achievement score of 39.53 with a standard deviation of 5.41 and a posttest mean interest score of 70.02 with a standard deviation of 5.02. The difference between the pretest and posttest mean achievement scores for the male group was 30.49. Also, female students exposed to same simulation aided flipped classroom had a pretest mean achievement score of 45.79 with a standard deviation of 4.60 and a post test mean achievement score of 71.31 with a standard deviation of 3.87. The difference between the pre test and post test mean achievement scores for female group was 25.52.

Although, for each of the gender, the posttest mean achievement scores was greater than the pretest mean achievement scores, with male having higher mean than their female counterparts. This indicated that male students under simulation aided flipped classroom have the highest mean gain in achievement than their female contemporaries. This result shows that SAFC leads to higher achievement in genetics in favor of the males than the females.

The above finding is further confirmed by data in Table 9 whose result showed that there is significant difference in the mean achievement score of male and female students exposed to SAFC. With an F-ratio of 45.918 and a significant value at .000 level, was less than .05 significant level, the null hypothesis was rejected. Invariably, there is a significant difference in the mean achievement score of male and female students taught genetics using SAFC.

The finding although in contravention with the works of Williams and Ogan (2022), Elia and Hamaidi (2023), Thomas (2021 and Gerald (2021) who in their separate studies revealed that there is no gender effect as relates to the flipped classroom. It also differs with the works of Atwa, Dim and Hussin (2020) whose research revealed that the simulation flipped classroom acted in favor of the females. However, the current findings are in consonance with the views of Okeh (2020), Clark (2022) among others who viewed that

gender differences exist in SAFC in favor of the males. The result of this study is also in agreement with the submission of Bichi et al (2017) and Hands and Greenlee (2017) who found in their separate studies that male students achieved significantly better than female students in science subjects. They opined that the sciences were attached masculine nature and is perceived as a disciplines for the male gender. Hence, male students outsmarted their female counterparts in achievement in biology under the simulation aided flipped classroom. It therefore goes that the null hypotheses of no significant difference in the mean achievement of male and female students is therefore rejected and alternative hypotheses formulated and accepted.

The Effect of SAFC on Male and Female Interest in Genetics

Results shown on Table 4 are the mean interest pretest and posttest scores of male and female students taught biology using the simulation aided flipped classroom. The results reveal that male students in the experimental group has pretest mean interest score of 11.75 with a standard deviation of 9.52 and posttest mean interest rating of 33.06 with a standard deviation of 15.75. The difference between the pre interest and post interest mean score of male was 21.31. On The female student exposed to SAFC had pretest mean interest score of 11.05 with a standard deviation of 3.64, and posttest score of 31.41 with a standard deviation of 17.80. The difference in the pre- and post- test interest rating for the female students was 20.36. That notwithstanding, for each of the groups, the post interest score was greater than the pre interest score with male students having slightly higher mean gain. This implied that both male and female students appear to have similar interest in genetics.

However**,** data in Table 10 showed that the difference in the mean interest score of male and female students exposed to SAFC is minimal. With an F-ratio of .308 and a significant p-value at .579 level, which is greater than the set 0.05 significant level, the null hypothesis was not rejected. Nevertheless, there was no significant difference in the mean interest score of male and female students taught genetics using SAFC.

The finding therefore is in line with the view of Okoye and Nnorom, (2016) who submitted that gender has no significant difference on students interest in biology. More so, the finding agrees with the studies of Okeke, (2016), Elian and Hamaidi (2023) among others who upheld that gender issues does not account for the degree of interest a students develops in sciences.

As such differences between boys and girls in the area of interest in science are now very small. From findings of the study, reduction in gender gap could be attributed to the teachers' effort in presenting classroom experience in such manner that challenged the female students to give their best. Furthermore, the findings contradicted the submissions of Okafor (2014), Baser (2006) as well as Iheanacho (2017) who opined that gender issues has significant effect on students' interest in sciences.

More so, overall increase in interest scores could also be attributed to the fact that their views and preconceptions were recognized, respected and integrated with the new knowledge which have boosted and developed their confidence in their ability to develop and

apply SAFC in the learning of biology. Nevertheless, the gender influence on interest of male and female students taught biology using SAFC was not significant.

Interaction Effect of Teaching Method and Gender on Students' Achievement in Genetics

Results in Table 5 showed that the male students taught genetics using the SAFC method had a pretest mean of 39.53 with an SD of 5.41 and a post-test mean of 70.02 with an SD of 5.02. The difference between the pretest and posttest mean was 30.49. The female students taught genetics using the SAFC method had a pre-test mean of 45.78 with an SD of 4.60 and a posttest mean of 71.31 with an SD of 3.87. The difference between the pretest and posttest mean was 25.52. Findings from Table 5 also showed that the male students taught genetics using the traditional lecture method had a pretest mean of 24.18 with an SD of 7.57. The difference between the pretest and the posttest mean was 15.42. The female students taught genetics using the traditional lecture method had a pre-test of 24.10 with an SD of 4.42 and a posttest mean of 36.32 with an SD of 4.94. The difference between the pre-test and posttest mean was 12.22. Although for each of the groups, the posttest means were greater than the pretest means, male and female students taught genetics using the simulation-aided flipped classroom method outperformed their counterparts in the traditional lecture method.

Results in Table 11 revealed, with respect to the interaction between each method and gender on students' achievement, an F-ratio of 3.527 was obtained with an associated probability value of 0.061. Since the associated probability value of 0.061 was greater than the 0.05 level of significance, the null hypothesis was not rejected. Hence, there is no significant interaction effect between teaching methods and gender on students' achievement in genetics.

The result obtained on the interactive effect of teaching methods and gender on students' achievement in genetics showed that the mean gain for male and female students taught genetics under SAFC was higher than the mean gain scores of those taught genetics under the traditional lecture method. This indicated that learning strategy and gender interact significantly to affect students' achievement in genetics. As such, the null hypothesis of no significant interaction between teaching methods and gender is rejected.

This finding supports the submission of Asuksoy and Sorakin (2021), among others, who opined that the interaction between learning strategy and gender is an essential part of the teaching and learning process that can improve students' achievement in science. However, since the interactive effect of gender and teaching methods was much more significant in this study, this implies that the observed difference in students' achievement in biology is a result of SAFC. As such, both male and female students under SAFC achieved higher than those under lecture methods.

Interaction Effects of Teaching Strategy and Gender on Students' Interest in Genetics

Teaching methods and gender have significant interactive effects on students' interest in genetics. The result of this study showed that the mean interest gain for males and females under SAFC was higher than that of those taught under the lecture method.

The findings of this study agree with the view of Stayer (2019), who opined that learning strategy influences learners' interest in the teaching and learning process. The findings of this research are consistent with the views of James (2020), Cagande, and Jugar (2021), who submitted that learning strategy enables students to develop interest in the task presented to them, which is exhibited through pre-intimacy as well as active participation in the given tasks, among others. However, since the interactive effect of gender and learning strategies was much more significant in this study, it implies that the observed difference in students' interest in biology is a result of the teaching strategy employed. Thus, both male and female students are motivated when SAFC is employed.

Conclusion

The SAFC is an effective innovative method in teaching and learning that has the capacity to improve students' achievement and interest in Biology among secondary school students in Nigeria, irrespective of their gender. It is one of the innovative techniques that can be used to engender a wholesome interest in both male and female students. This is apt as biology is the master of all sciences, and hence a boost in interest and achievement in biology could boost national development in areas of medicine, food processing, and so on.

Recommendations

The following recommendations were made:

1. The use of this instructional strategy should be fostered and encouraged among biology teachers.
2. From the study SAFC improved interest and achievement, as such curriculum planners, educational administrators as well as the principals and biology teachers should use it as the point of reference in planning the curriculum and formulating other educational policies in biology.
3. In line with fostering adequate mastery of SAFC among biology teachers, organization of conferences, seminars, workshops must be prioritized by government.

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