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Use of 5E Learning-cycle and Concept-mapping Strategies for Improving Students' Performance in Genetics in Secondary Schools in Kwara State, Nigeria

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Abstract: The continuous explosion of discoveries in field of science and technology in this 21st century calls for shift from conventional teaching methods to a more innovative teaching strategies in Nigerian secondary schools. Instructional strategies adopted by teachers have been linked by researchers to students' conceptions, misconceptions, difficulties of some concepts as well as poor performances in science subject like Biology at the senior school certificate examinations in Nigeria. Genetics is one of the concepts in Biology that was reported by researchers to be difficult to teach by teachers and difficult to learn by students in secondary schools in Nigeria. This study examined the effect of using 5E learning-cycle and concept-mapping in teaching genetics to senior school students offering biology. The study is a quasi-experimental type. Sample comprised of senior school two students in public secondary schools in Ilorin city. The study is a quasi-experimental type involving pretest, posttest, non- randomized and non-equivalent control groups. All Senior School two (SS II) Biology students were the targeted population. The target population will not be preparing for WASSCE. A purposive sampling technique was used to select co-educational government secondary schools in three senatorial districts. A Performance Test on Genetics (PTG) was used for data collection. Data collected were analyzed using mean and ANCOVA statistical tool. The study revealed that both learning-cycle and concept- mapping had a positive effect on the performance of the experimental groups. It means there is a significant difference between the experimental and control groups and also, no significant difference between the performance of male and female students. It was therefore recommended among others that teachers should employ these strategies to teach biology particularly genetics.

Keywords: Concept-mapping; Instructional strategy; Genetics; Learning-cycle; Performance.

Introduction

Biology is one of the natural science subjects in offered by Nigerian secondary school students. It is regarded as the most popular of the three natural science disciplines amongst secondary school students in Nigeria (Jibril, Bello & Abimbola, 2015). In same vein, Biology as a science subject is regarded as the simplest to understand among all the science subjects that usually attract the widest enrolment among Nigerian students at the Senior School Certificate Examinations (Adewale, Nzewuihe & Ogunshola, 2016). Biology being a natural science discipline is made up of several disciplines among which are Botany, Zoology and Micro-Biology and sub-discipline; Genetics, Ecology, Anatomy, Embryology, Physiology, Molecular Biology, Biochemistry, Space Biology, Paleontology, Cytology, and Taxonomy (Ndu, Asun & Aina, 2010; Josh & Green, 2013; & Edna, 2014). Of all these sub-disciplines, Genetics which is the study of heredity or how living organisms transfers traits like observable or detectable characteristics from generations to generations (Armstrong and Wilkinson 2020), is an important aspect of human development that is difficult to teach and learn, thereby promoting rote learning of the concept (Abimbola 1998). Therefore, the need for conceptual understanding of genetics is very important. To do this, teachers needs to employ innovative strategies to teach so as to motivate and encourage critical thinking and more conceptual understandings of genetics. Consequently, scholars in the field of science education have emphasized on the adoption of students' centered innovative instructional strategies in this 21st century (Jibril, Babalola & Abimbola, 2019). Thus, led to the use

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of these strategies i.e. learning cycle and concept mapping strategies in this study.

Learning-cycle which is one of the instructional strategies to be considered in this study is activity-oriented innovative methods that promotes students' meaningful understanding of the scientific concept, explores and deepens that understanding in application to a new situation (Sadi & Cakiroglu, 2010). It is an active method concerned with both the entire content to be learnt and learners' cognitive structures. It deals with the selection and organization of content and experience to facilitate the materials to be learnt within learners' cognitive structures and creates new knowledge; structures to bring about cognitive development (Qarareh, 2012). Learning-cycle first evolved from three phases, which consisted of exploration, invention, and discovery. The three phases of Learning-cycle were introduced by Karplus and Atkin (1962). Due to the complexity of the meanings of these phases, exploration, invention and discovery, Karplus later revised these names to; exploration, concept introduction and concept application (Hanley, 1977).

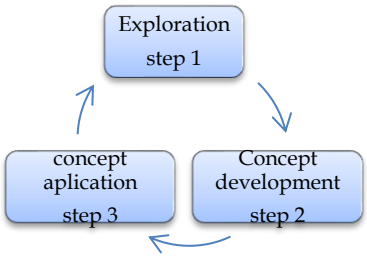

Figure 1. Three phases Learning-cycle Adapted from Walbert (2003)

The three phases cycle was later expanded to five phases; namely Engage, Explore, Explain, Elaborate and Evaluate, that is, 5E cycle (Byee,1997). The 5E Learning-cycle was developed by the Biological Science Curriculum Study(BSCS) in 1992. (Byee,1997; Ergin, Kanli,& Unsal, 2008 & Ajaja, 2013).

At the **engagement phase**, the teacher must introduce a task, pre-assess the knowledge of the learners and connect past learning and experiences by asking invocating questions. The goal here is to spark students'/learners' interest and involvement. While learners are the center of the action in the **exploration phase**, they are to take part in activities that will enable them manipulate the teaching aids or work with materials that will guide their understanding of the content of instruction or lesson. It is a 'hands- on' active phase of learning. At this phase, learner's participation and interaction are ensured by the teacher. At the **explanation phase**, teacher interprets the activities of the previous phases. Learners are guided to put observations, questions and experiences into simple understandable language, i.e., to communicate their discoveries or findings. At this stage, the teacher introduces explanations, definitions, new vocabulary or guides the learner in understanding and stating the new concept. The knowledge or experiences gained by learners in the previous phases are extended to real situation at the **elaboration phase**. The teacher introduces new information that extends what the learners have learnt during their activities. Teacher poses varying questions to the learners, to provide answers based on their previous knowledge of the concept. This provides for further insight and understanding. **Evaluation phase** is a continuous process that takes place in each phases of the cycle. Teacher at this phase have access to evaluate the progress of learners. Oral questioning method can be employed in between the phases while written test can be employed at end of the whole exercises. Therefore, the extensive and logical presentations of learners' activities in 5E learning phase prevents rote learning and passive transmission of content of instruction. Thus, making it more suitable for this research work.

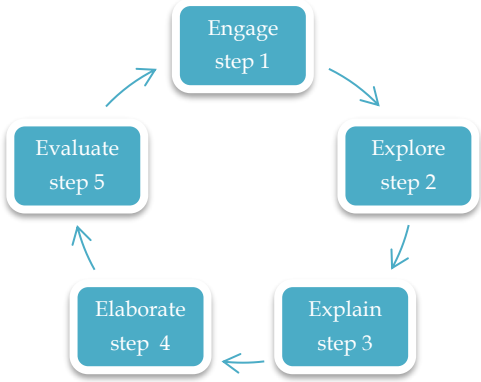

Figure 2. Five phases Learning-cycle Adapted from Lalla (2014).

Concept-map is the second strategy to be employ to teach genetics concept in this study. As an instructional strategy, its involve the use of a node-link diagram showing the semantic relationships among concepts. It is a mapping technique that employ the use of nodes, arrows as linking lines and linking phrases to describe the relationship between several nodes (Schwendimann,2014). Also, the mapping strategy is aimed at presenting knowledge visually to learner to help organize and structure information in their cognition (Jennings,2012). The knowledge may be represented using images, photos, colours etc. to highlight different concepts and their links or by identifying key concepts by name or title. Thus, enclosing these concepts in a visual box after then using a connecting navigation to show the relationship.

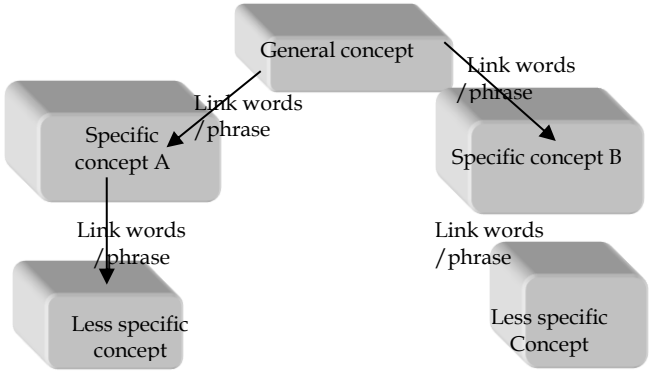

Figure 4. Example of plain Concept-map drawing
Adapted from Novak (2004)

Concept mapping is embedded with a lot of learners' activities that can trigger critical thinking that enhances cooperation among learner as well as understanding of difficult concepts in biology. Against the backdrops, the study intends to examine the applicability and effectiveness of these instructional strategies (i.e. learning cycle and concept mapping) when employed to teach genetics and how it can be adopted by teachers to improve Biology students' academic achievement in Senior School Certificate Examination in Kwara stat

5E learning Strategies

Asrizal, Yurnetti and Usman (2022) used 5E Learning-cycle model with ICT thematic science teaching material to develop students' 21st century. A quasi-experimental design with randomized control group posttest was employed for the study. The result showed a positive effect of 5E learning-cycle on students' skills. The experimental groups taught with 5E Learning-cycle model were 34 students while control groups exposed to traditional method were 32 students. Similarly, Bahardir and Dikmen (2022) study on 5E model on students' academic achievement and Shivan and Mohalik (2022) study on integrating 5E learning model on higher thinking in biology at secondary school level revealed a positive effect on students' academic achievements in the science subjects. However, these studies were conducted outside the county.

Earlier on, Aktas (2013) compared 5E learning model and cooperative learning on students' attitudes towards Biology lessons. A quasi-experimental design was employed. A total of 93 students in third-grade science were sampled. The lesson units taught were heredity genetic engineering and biotechnology in Biology. The findings revealed that 5E learning model was the most effective method. Also, it was proven that 5E learning method increases students' attitude towards the Biology lessons. Bulbul (2010) examined the effect of 5E Learning-cycle model accompanied with computer animations on understanding of diffusion and Osmosis concepts. The study was a quasi-experimental design with non-equivalent control group conducted on ninth-grade students in Island. The instruments used in the study were Diffusion and Osmosis Diagnostic Test (DODT), Diffusion and Osmosis Achievement Test (DOACH), Attitude Scale toward Biology (ASTB) and Science Process Skill Test (SPST). Data collected were analyzed using ANOVA and ANCOVA. The findings revealed a significant difference in favour of the experimental group. Similarly, same year, Sadi and Cakiroglu (2010) examined 5E Learning-cycle on students' human circulatory system achievement; the study was conducted with 60 students in 11th grade from four classes of two teachers in a private high school in Ankara, Turkey. Each class of each teacher had both experimental and control groups. The instruments used in data collection were Human Circulatory System Achievement Test (HCSAT) and observation checklist used to confirm proper treatment implementation. The achievement test (HCSAT) was applied twice as pre-test and posttest to the two groups. Data collected were analyzed using analysis of variance (ANOVA). The result revealed that there was a significant difference. Contrary to this present study, the concept taught in these studies were not genetics and the attitude students which was a variable in the study would not be considered by the researcher.

Ajaja and Erawoke (2012) employed Learning cycle strategy to test the academic achievement of students in Biology and chemistry. The samples of the study were six senior secondary schools, 112 science students and 12 Biology and chemistry teachers. The design of the study was 2 x 2 x 3 x 6 pretest, posttest, non- equivalent control group. A researcher designed copies of questionnaire on Knowledge and Use of Learning-cycle (KULC,) Biology Achievement Test (BAT) and Chemistry Achievement Test (CAT). Analysis of Covariance (ANCOVA) and t-test statistics were used to analyze the data collected. The results of the study revealed a significant effect on students' achievement in both Biology and chemistry. no significant difference between the scores of males and females taught with Learning-cycle. Therefore, this present study would consider gender as a variable in order to affirm or reject the finding. Also, Sam, Owusu and Anthony-Krueger (2018) examined the effect of 3E, 5E and conventional teaching approaches on students' achievement in biology. The study employed a mixed method approach. A random sampling technique was employed to select three science classes in three Senior High Schools in Cape Coast Metropolis. Researcher designed test and semi structured interview were used to collect data. The students in the experimental groups were taught with 3E and 5E learning cycle while those in the control group were taught with conventional method. Data collected were analyzed using ANCOVA

and independent t-test. The study showed that that, experimental groups performed better as compared to the control group. The results from the study also showed that the 5E learning cycle approach was most suitable for the lesson. However, the study employed a random sampling technique and failed to consider if students' gender and cognitive level has influenced the results.

Table 1. Review of recent literatures on 5E learning cycle

Author	Field	Method	Findings	Location	FOCUS
Lasaiba, M. (2023)	(Science) Geography	Mean and %	+	Indonesia	Optimizing students' activities and learning outcomes
Varoglu, L., Yilmaz, A. & Sen, S. (2023)	Chemistry	Standard Deviation, t-test	+	Ankara, Turkiye	Conceptual understanding
Agbidye, A. & Oyinlo, F. A. (2022)	Physics	Mean, Standard Deviation and ANCOVA	-	Nigeria	Critical thinking
Bahadir, F. & Dikmen, M. (2022)	science subjects & social sciences	Mean, Standard Deviation	+	Turkey	Students' academic achievement
Eroglu Seyide & Oktay Bektas (2022)	Chemistry	ANCOVA	+	Turkey	Academic achievement and scientific creativity
Resmol, K. & Leasa, M. (2022)	Biology	ANCOVA	+	Indonesia	Students' motivation
Jesulowo, J. K. (2021)	Biology	Mean, Standard Deviation, t-test, MANOVA	+	Nigeria	Creativity, performance and retention
Riza Solar (2021)	Physics	ANOVA	-	Turkey	Academic achievement and self-efficacy of students
Tenzin, S., Kinley, K. & Wangchuk, T. (2021)	Biology	Mean and Standard Deviation	+	Hutan	Conceptual understanding
Priyadharshini, N. & Singaravelu, G. (2019)	Science measurement	Mean, Standard Deviation & t-test	+	Bharathiar, Coimbatore	Learning science among middle school students.
Febrianto, P., Ika, Y. N., Ani, R. & Bambang, S. (2018)	Physics	Percentage	+	Indonesia	Conceptual understanding and learning motivation
Opera M. (2018)	Chemistry	Mean, Standard Deviation & ANCOVA	+	Nigeria	Students' interest
Yusuf, A. & Adesegun, O. (2018)	Civic Education	ANOCA	+	Nigeria	Academic performamce

Table 1, revealed that most of the recent studies conducted in the different fields of knowledge on 5E learning cycle strategy showed a significance (+) on students' academic achievement (Lasaiba, 2023; Varoglu, Yilmaz, & Sen, 2023; Agbidye & Oyinlo,2022 & Jesulowo,2021). While Agbidye and Oyinlo (2022); Riza (2021) studies revealed no improvement on students' academic achievement. This study would contribute to the reviewed literatures by examining the direction of significance of 5E learning cycle on concept genetics in biology

concept mapping strategy

Several studies were also conducted on the second strategy which is the concept mapping strategy, among which were; Aziz and Rahman (2015) examined Concept-mapping students' achievement in secondary school science. The study was a quasi-experimental type. Participants were purposively sampled. A researcher designed test entitled 'Test of Achievement in Science' (TAS) was used to measure the achievement. Data were analyzed with mean, standard deviation and t-test statistics. Results revealed a positive improvement from students' scores. Similarly, Ogbonna (2014) examined how Concept-mapping improve students' achievement and interest in some concepts from organic chemistry. A quasi experimental design of non- equivalent pre-test post-test control group was adopted for the study. A Random sampling technique was used to assigned students into experimental and control groups. Organic Chemistry Achievement Test (OCAT) and Organic

Chemistry Interest Scale (OCIS) were used for data collection. Data collected were subjected to Analysis of Covariance (ANCOVA). The study revealed an improvement on students' achievement as well as interests. Contrary to this present study, the studies did not consider gender as variable.

In addition, Sakiyo and Waziri (2015) conducted a study to examine the effect of Concept mapping teaching method on senior school students' academic achievement in biology. The study adopted a quasi-experimental design. The topics taught were nutrition, habitat and nutrient cycle in biology. A Biology Students' Achievement Test (BSAT) was used for data collection. Data collected was analyzed using one-way Analysis of Covariance (ANCOVA). The study revealed that a higher academic achievement of these students in biology. Also, no significant difference between male and female students' achievement. However, no gender influence. Contrary, Udeani and Okafor (2012) study revealed a gender influence when comparism were made between expository and Concept-mapping instructional strategy on slow learner achievement photosynthesis. Data collected were analyzed using t-test. The study revealed that the group taught by the Concept-mapping strategy performed better than those taught with expository strategy.

Statement of the problem

Genetics has been reported by teachers and students to be one of the difficult biology topics in secondary schools in Kwara State over the years (Abimbola,1998 & Jibril, Bello & Ayinde, 2021).Researchers have employed different strategies to aid the teaching of the concept genetics in order to maximize meaningful learning, conceptual understanding, eliminates misconception as well as improved academic achievements of senior school students in Biology and genetics in particular. However, the recent Chief Examiners reports at the Senior School Certificate Examinations still revealed that performances of students in genetics concepts is still not appreciated. This prompt the Researcher to try out an innovative instruction such as learning-cycle and concept-mapping instructional strategies in this era of daily scientific advancement in science Education. Artun and Costu (2012) reported that science education studies have revealed that students' different conceptions in science are very tenacious and that traditional instructional method is no more effective in promoting conceptual understanding. Research results have supported the effectiveness of both 5E Learning-cycle and concept-mapping instructional strategies. Several studies on 5E learning-cycle revealed significant effects on students' academic achievement using 5E learning cycle strategy (Sam, Owusu and Anthony-Krueger, 2018; Jibril, Babalola & Abimbola,2019 & Jibril, Bello & Ayinde,2021; Asrizal, Yurnetti & Usman, 2022). However, Riza (2021) study found students' achievement not significant. As well, some studies on concept mapping revealed a significant on students' academic achievements (Udeani & Okafor,2012; Aziz & Rahman,2015; Sakiyo & Waziri,2015). Nevertheless, Lalla (2014), revealed no significant effects on students 'academic achievement.

Importantly, during the past decades, researchers have continued to find out if gender stereotype is a predictor of academic achievement in science, but results are yet to produce a conclusive statement. Some findings from researches on Learning-cycles indicated that gender is not a determinant of students' academic achievement in science (Generaux,2014; & Ajaja, 2013). While some revealed that gender stereotype played a significant role in the academic achievement of students in science (Abdulrahim,2018; Ercan, 2014; Opara & Waswa, 2013).

Considering the foregoing, more studies on 5E learning-cycle and concept-mapping are required. Moreso, there is need to examine the effectiveness of these instructional strategies on concepts difficult to teach and learn in Biology and on genetics particular. Therefore, this study differs by comparing the effectiveness of both 5E learning-cycle and concept-mapping strategies on teaching of genetics in Biology among secondary school students in Ilorin, Nigeria. Importantly, the study intends to investigate the influence of gender to affirm the direction of these instructional strategies in terms of gender stereotype.

Research Hypotheses

The following null hypotheses would be tested in this study:

1. There is no statistically significant difference in the achievement of senior school students' taught genetics using Learning-cycle, Concept-mapping strategies and those taught with conventional method.
2. There is no statistically significant difference in the achievement of male and female senior school students' taught genetics using Learning-cycle instructional strategy.
3. There is no statistically significant difference in the achievement of male and female senior school students' taught genetics using Concept-mapping strategy.

Method

The study was Quasi-experimental study of non-equivalent, on-randomized pretest; posttest control group design. The sample comprised of 209 students

from intact classes from three private secondary schools in Ilorin city. A purposive sampling technique was used to select the schools for the study. The Senior School two (SSII) Biology students were the target population. The target population were not preparing for WASSCE. Biology teachers' qualifications, school location, were criteria considered for the selection of schools. Instruments employed for the study was a researcher-designed Performance Test on Genetics (PTG). The Research instruments were given to three experienced Biology teachers and two Biology educators from the Department of Science Education, University of Ilorin, Nigeria for face and content validity. Also, the draft of the PTG was given to an expert in the field of measurement and evaluation for standard of the items. Reliability of the instrument was determined using test-retest method of three weeks' interval on the students of non-participating school. A reliability of 0.65 was obtained using Person product- moment correlation coefficient.

Procedure for Data Collection

The researcher sought the permission to conduct the study in the sampled schools by presenting an introduction letter to the Principals of the selected schools for consideration. With the permission, the researcher was introduced to Biology teachers of the schools for familiarity and arrangement was made for the study to take place. The researcher and Biology teachers who were the Research assistants distributed the consent forms to the students. The form was given to each student to be completed and returned to the Research assistants of each school. These consent forms were given to seek students' consents to participate in the study. The copies of the collected consent forms were returned to the Researcher. Then pretests were administered to the participating students in both experimental and control groups before the commencement of the teaching. This was used to determine the students' prerequisite knowledge genetics as well as the equivalence of the groups. The experimental groups were taught using 5E learning-cycle and concept-mapping and control group with Conventional method. Posttest was administered to all the groups at the end of the lessons**.**

Result and Discussion

Data collected from the study were analyzed with descriptive and inferential statistics. All the research questions were answered with mean and research hypothesis were tested with ANCOVA at 0.05 level of significance.

Research Question 1: What are the differences in the achievement of senior school students taught genetics using 5E Learning-cycle, Concept-mapping and conventional method?

The result from table 2 revealed the mean scores for the experimental groups; 1, 2 and the control group. The result revealed that experimental group 1 has an approximate mean score of 35.58, experimental group 2 has approximate mean of 35.45 and control group has an approximate mean of 18.12. This showed that learning cycle instructional strategy has a positive effect on the achievements of students.

Table 2. Mean Results for The Three Groups

Groups	N	X
Experimental group 1	71	35.5775
Experimental group 2	65	35.4462
Control	73	18.1233

Hypothesis 1: There is no statistically significant difference in the achievement of senior school students' taught genetics using Learning-cycle, Concept-mapping strategies and those taught with conventional method.

From the result shown in table 3, the calculated F-value is 175.397 computed at 0.05 level of significance. Since the calculated level of significance 0.000 is less than the table level of significance (0.05), ($P<0.05$). Hypothesis is hereby rejected, which means that there was a significant difference in the achievement of students that were taught ecology exposed to learning cycle instructional strategy and those not exposed to cycle instructional strategy. This means that those students in the two experimental groups achieved better than those in the control group.

Table 3. ANCOVA Results for the two Groups ANCOVA Analysis Result of the Two Experimental Groups and the Control Group.

Source	Type III Sum of Squares	Df	Mean Square
Corrected Model	16803.257[a]	3	5601.086
Intercept	18382.834	1	18382.834
Pretest	2435.030	1	2435.030
Groups	13440.146	2	6720.073
Error	7854.246	205	38.313
Total	205803.000	209	
Corrected Total	24657.502	208	

a. R Squared = .681 (Adjusted R Squared = .677)

Research Question 2: What is the difference in the achievement of male and female senior school students taught genetics using 5E Learning-cycle?

Table 4 reveals the mean scores of Males as 37.08 and female as 34.76. This implies that both gender group performed positively after treatment.

Table 4. Mean Results for the 5e Learning-Cycle Based on Gender

Gender	N	x
Male	25	37.08
Female	46	34.76
Total	71	

Hypothesis 2: There is no statistically significant difference in the achievement of male and female senior school students' taught genetics using Learning-cycle instructional strategy.

Table 5 revealed that the calculated F is 1.350 with 1 degree of freedom. Since the calculated significant is 0.249 greater than the table value of 0.05 (P>0.05). The null hypothesis is not rejected, this implies that there was no significant difference in the achievement of male and female students when taught ecology using learning cycle instructional strategy only.

Table 5. ANCOVA Analysis of the Post-Test of Male and Female Senior School Students in Experimental Group 1

Source	Type III sum of square	DF	Mean square	F	Sig.	Remark
Corrected model	486.053[a]	2	243.026	7.925	.001	
Intercept	9843.938	1	9843.188	320.983	.000	
Pretest	398.938	1	398.938	13.009	.001	
Gender	41.410	1	41.410	1.350	.249	NS
Error	2085.271	68	30.666			
Total	92440.000	71				
Corrected Total	2571.324	70				

a. R squared = .189 (Adjusted R squared = .165)
b. NS- No significant difference

Research Question 3: Is there any difference in the achievement of male and female senior school students taught genetics using Concept-mapping strategy?

Table 6 reveals the mean scores male and female exposed to concept mapping strategy as 35.00 and 35.70 respectively. This implies that both group of gender benefited with almost no difference in their performance.

Table 6. Mean score for concept mapping based on gender

Gender	N	x
Male	25	35.00
Female	40	35.70
Total	65	

Hypothesis 3: There is no statistically significant difference in the achievement of male and female senior school students' taught genetics using Concept-mapping strategy.

Table 7 revealed that the calculated F value is 0.018 at 1 degree of freedom. Since the calculated significant is 0.893 greater than the table value of 0.05 (P>0.05) level of significance. The null hypothesis is not rejected, that is, there was no significant difference in the achievement of male and female senior school students when taught genetics using concept mapping strategy. This implies that both male and female senior school students achieved.

Table 7. ANCOVA Analysis of the Post-Test for Gender in the Experimental Group 2

Source	Type III sum of square	DF	Mean square	F	Sig.	Remark
Corrected model	1451.338[a]	2	725.669	15.705	.000	
Intercept	6000.203	1	6000.203	129.860	.000	
Pretest	1443.251	1	1443.251	31.236	.000	
Gender	.847	1	.847	.018	.893	NS
Error	2864.724	62	46.205			
Total	85984.000	65				
Corrected Total	4316.062	64				

a. R squared = .336 (Adjusted R squared = .315).

Conclusion

From the results, it was concluded that 5E learning-cycle and concept-mapping instructional strategies improves students' understanding and performance in genetics as compared with conventional teachers' methodology. This evident as revealed from the hypothesis one, which was rejected. This result on learning-cycle is in line with studies of Lasaiba, 2023; Varoglu, Yilmaz, & Sen, 2023; Agbidye & Oyinlo,2022 &

Jesulowo, 2021 as well as on concept mapping strategy studies of Abdulrahim, 2019, Eneogu and Ugwuanyi (2017), Aziz and Rahman (2015) on Concept-mapping. Also, the finding revealed that students' gender has no influence on both 5E learning-cycle and concept mapping strategies. This implies that two strategies are not gender biased.

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Conflicts of Interest
The authors declare no conflict of interest

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