

Science Text Cards, Crossword Puzzles on Students' Academic
Retention in Biology in South-South Region, Akwa Ibom State, Nigeria

Oboho, Daniel E., Atabang, Atim A. (PhD),
Akpan, Anyanime O. (PhD),

&

Duru, Chukwudi M. (PhD)

Department of Science Education, Akwa Ibom State University,
Akwa Ibom State, Nigeria

^{1,2,3,4}Email: ¹obohodan@gmail.com ²atim_itighise@yahoo.com

³yaniokop@yahoo.com ⁴duruchukwudi06@gmail.com

¹08038837845 ² 08146668803 ³ 08023319141 ⁴08035311168

Abstract

The study investigated the effects of science text cards, crossword puzzle on students' academic retention in Biology in south-south region of Akwa Ibom State. To achieve the purpose of the study, three research questions and three hypotheses were formulated to guide the study. Quasi experimental research design was adopted and the study was conducted in south-south region of Akwa Ibom State. The Population of the study consisted of all the 1423 Senior Secondary Two (SSII) Biology students in the six public secondary schools in south-south region of Akwa Ibom State, Nigeria during the 2024/2025 academic session. The sample size for the study was One Hundred and Fifty (150) Senior Secondary Two (SS2) Biology students selected from their intact classes. Criterion and simple random sampling technique was used for the selection of schools for the study. Genetics Retention Test (GRT) was used as instrument for data collection. The instruments was duly validated and subjected to reliability analysis using Kuder Richardson 20 (K-R20). The result showed a reliability coefficient of 0.83 and was deemed appropriate for the main study. Descriptive statistics of mean and standard deviation were used in answering the research questions while analysis of covariance was used in testing the hypotheses at 0.05 alpha level. From the result findings of the analyses carried out, it was concluded that there was a significant difference in students' academic retention when taught the concept of genetics based on science text cards, and crossword puzzles as students in the experimental groups retained better than their control group counterparts in Biology. Within the experimental groups, those taught with science text cards retained better followed by crossword puzzles; male and female students in the experimental groups retained better than their counterparts in the control groups. Within the experimental groups, the female students retained slightly better than their male counterparts; the interaction effect between treatments and gender given, affect significantly the retention of the students in the concept of genetics in Biology. Based on the findings, it was recommended, among other, that educational authorities should consider incorporating the use of science text cards and crossword puzzles

into the curriculum for Biology. This can help standardize effective instructional practices across schools.

Keywords: Science text cards, Crossword puzzles, Gender, Genetics, Academic Retention and Biology

Introduction

Science education is a critical component of the school curriculum, with Biology serving as a foundational discipline that deepens students' understanding of living organisms and their ecosystem. Biology as one of the science subjects is concerned with the study of living things including their functioning, structure, growth, evolution, distribution, identification and taxonomy (Atabang, 2024; Duru, 2025). It is central to many science related courses including medicine, biochemistry, pharmacy, nursing science and agriculture. Being a science of life, Biology is one of the core science subjects taught in the senior secondary schools. Hence, it occupies a very important position in the secondary school curriculum. In Nigeria, the secondary school Biology curriculum is designed and developed to prepare students to acquire adequate laboratory and field skills, meaningful and relevant knowledge in Biology and also to enable students apply scientific knowledge to everyday life in matters of personal, community, health and agriculture among others (Duru, Uko, & Utibe, 2024). Biology is introduced to students at the senior secondary school level as a preparatory ground for human development, where career abilities are groomed, potentials and talents are discovered and energized. Today, Biology pervades literally every field of human endeavors and plays a fundamental role in educational advancement (Uko, Duru, Babayemi, & Atabang, 2025; Aninweze, 2014).

Duru, Uko, and Utibe (2023); Adam, Lameed and Adelabu (2023) highlights the importance of Biology to include helping individuals to understand the parts of his/her body and their functions; enabling one to question superstitions due to sustained interest arising from comprehension of the cause of events; understanding and appreciating life; bringing into focus the need to maintain good health; inculcating the individual scientific skills and attitudes in his approach to personal and societal problem; imparting factual knowledge and stimulating scientific reflective thinking so as to produce a better informed individual; promoting the individual for career choice. The study of Biology in senior secondary schools is expected to equip students with useful concepts, principles and theories that will enable them face the challenges before and after graduation. The subject aims at equipping the learner with knowledge, skills and attitudes that are necessary for controlling and preserving the environment; enabling the learner to appreciate humans as the broader community of living organisms (Duru, Uko, & Utibe 2024; Umoke & Nwafor, 2014). The importance of Biology and Biology education for sustainable national development cannot be overemphasized. Biology has contributed to the growth and development

of new and better drugs and vaccines against many human and animal diseases and has also contributed towards the conservation of the environment and endangered species (Duru, 2025).

Some topics can sometimes be difficult especially when describing things that cannot be seen or abstract concepts that cannot be fully comprehended at the first time (Atabang, 2024). Some of the topics taught in Biology that students perceive as abstract are genetics, evolution, physiology, micro-organisms, skeletal system among others (Fasasi & Oladejo, 2022). Research studies have shown that a number of concepts in Biology which include Genetics posed difficulty for students to understand and grasped (Duru, Uko, & Utibe, 2023; Esiobu & Soyibo, 2018). Also, some students have the notion that the concept of genetics in Biology is abstract and extremely technical and require only rote memorization to pass (Ogunbanwo, 2019). However, many teachers and students regard the topic of Genetics as very difficult, both to teach and to learn (Okebukola, Ige, Oyeyemi, Olusesi, Owolabi, Okebukola & Osun, 2016). Fasasi and Oladejo (2022), referring to these difficulties, argued that as the revolution in the field of Genetics continues, the web of abstract concepts becomes increasing complex.

According to Akintola (2019), students' understanding of fundamental of genetics concepts suggest that current instruction in genetics leaves students with insufficient understanding of the technological advances in genetics that they may encounter in their everyday lives, such as genetics counseling and screening. Nor are students informed enough to understand and participate in current debates involving genetic issues such as genetically modified foods, cloning and gene therapy. Conversely, teachers neglect from teaching this topic because of its complexity; students find it difficult because it is perceive as being difficult, abstract and boring hence; students may achieve low academic success and retain poorly in examinations (NERDC, 2015).

Biology is a subject which students must pass if their overall success is to have any value. A credit pass in Biology is a compulsory requirement for any student seeking admission into all the institutions of higher learning in Nigeria. The knowledge of Biology is needed for National development and global competitiveness in the area of medicine, education, agriculture, physical and health education, especially in sports and environmental studies amongst others (Duru, 2025). It will also help to perpetuate desired favorable traits in the production of high breeds of crops and animals through hybridization and cloning respectively, it can also help in the conservation of natural resources and checkmating population explosion.

Furthermore, the West African Examination Council (WAEC) Chief Examiners, report 2021, 2022, 2023, 2024, 2025 confirm that students retention in Biology is poor (WAEC, 2025). According to the report, the poor academic retention ability in Biology is attributed to difficulty in interpreting data and graphs, particularly

in the objectives test section, lack of understanding of key biological concepts such as genetics, photosynthesis and respiration, poor laboratory skills including difficulties with measurement and observation and above all poor teaching approaches adopted by teachers. According to reports, teachers should adopt more interactive and engaging teaching approaches to help students better understand key concepts, teachers should place greater emphasis on innovative instructional strategies to help students develop practical skills, and that students should practice more objective tests to improve their interpretation and analytical skills. Also, the high rates of failure recorded by Biology students in schools and colleges in Nigeria have been a major concern to researchers.

Consequently, the low retention in Biology in external examinations had been traced to the use of conventional teaching approach and other factors that does not put into consideration the students' activities in teaching and learning processes (Oluwaseun, Onovroghene & Avodele, 2018; Uko, Duru, Babayemi, & Atabang, 2025). It has been shown that Biology concepts such as genetics among others pose strong resistance to the conventional teaching approach used by teachers and this hinders the realization of Biology objectives and as well as lesson objectives. This is because, conventional approach may lack student to student help, interaction and cooperation needed for effective teaching and learning of difficult concept (Oladejo & Ebisin, 2021).

The use of appropriate teaching approaches in teaching Genetics could help to assuage this poor academic retention. Instructional resources are those materials used in the classroom and science laboratory for instructions and purposes of demonstration by teachers and students. The term instructional approach is used to denote resource materials/methods, anything which can help to transmit learning experiences through any of the senses of touch, sight, smell, taste and hearing (Akpan, 2022; Moses, 2020). They are adopted by teachers in classroom to aid in the attainment of specific learning objectives set out in classroom plans (Etop, Ibora & Obogo, 2023). Studies have shown that the use of instructional resources has improved achievement and retention (Okori & Jerry, 2017). The teaching of Biology without appropriate instructional resources may certainly result in poor academic achievement and retention. According to Osinubi and Okebukola (2014), the teaching of Biology cannot be done effectively without interaction between the teacher, students and the environmental resources. The Biology curriculum is planned and designed to enable the teacher use activity oriented, student-centered approach to teach (Oluwaseun, Onovroghene & Avodele, 2018).

However, evidence from research has shown that most teachers in Nigeria use verbal exposition of scientific principles, facts and concepts thus, academic retention of Nigerian students in ordinary level Biology is persistently poor over the years (Uko, Duru, Babayemi, & Atabang, 2025; Adam, Lameed & Benson, 2023). This has been a major source of concern for researchers, the school administrators,

parents and the government at large. In an attempt to facilitate the teaching of such content, teachers must adopt resources, analogies, contextualization, multimedia resources (slides), games and physical models (cards or plastic models to represent elements). The combination of these approaches/resources can make learning concepts more significant, easy and meaningful to students and increasing the interest of the students in Biology. Utilizing appropriate teaching resources has proven over time to improve students' academic retention on what was taught. However, research suggests that students face challenges in comprehending and retaining complex biological concepts, leading to lower academic retention rates in the subject (Gega et al., 2017). To address these issues, educators have been exploring innovative instructional strategies to enhance students learning experiences in Biology. One instructional resource strategy that has been shown may improve students' academic retention in Biology in this study is the use of science text cards.

Science text card is a paper containing a picture and name of the picture." Science text card" is small cards that have picture, word, text or symbol for individual to study a particular topic or describe something (Brady & Fisher, 2016). Science text cards are portable, concise resources that contain key information, definitions, and explanations of Biology concepts. Research has suggested that the use of science text cards can help students reinforce their understanding of important concepts and improve retention of crucial information (Jones & Peterson, 2018). By presenting information in a structured and organized format, science text cards serve as valuable study aids that can help students reinforce their knowledge and review essential concepts in Biology (Montgomery & Richards, 2018). The researcher further maintains that science text cards are widely used as a learning drill to aid memorization by way of spaced repetition. Science text cards are useful for drilling new letters, syllables, words, and other information. It is an innovative teaching resource that is normally used in a classroom, but can also be used more informally (Itighise, 2016). Science text cards can bear vocabulary, historical dates, formulas or any subject matter that can be learned via a question and answer format. In addition to science text cards, another instructional resource strategy that has been shown may impact on student' academic achievement and retention in Biology in this study is the use of crossword puzzle.

A crossword puzzle usually takes the form of a square or a rectangular grid of white and black-shaded squares. The game's goal is to fill the white squares with letters, forming words or phrases, by solving clues, which lead to the answers. In languages that are written left-right, the answer words and phrases are placed in the grid from left to right and from top to bottom. The shaded squares are used to separate the words or phrases (Olagunju & Babayeni, 2014). According to Wordu and Atabang (2024), these puzzle though may not completely replace the traditional way of obtaining theoretical knowledge but can be used as an adjunct to reinforce acquisition of content and enhance the problem-solving skills (Rahman, et al., 2017). Crossword

puzzles are engaging and interactive tools that can help students' review and practice Biology vocabulary and concepts. By completing crossword puzzles, students can enhance their understanding of key terms and relationships between different concepts in Biology. Crossword puzzles have emerged as a popular instructional tool for enhancing students' engagement and knowledge retention in Biology. Crossword puzzles provide a fun and interactive way for students to review and practice Biology vocabulary and concepts, thereby strengthening their grasp of essential content (Kim, 2019). However, some variables such as gender may influence how students learn and their academic retention, thus it is important to consider these intervening variables in research in science education.

Gender is a socially constructed definition of male and female. Gender is the range of characteristics pertaining to and differentiating between, masculinity and femininity (Atabang & Umanah, 2024; Duru, Uko & Utibe, 2024). There has been a continuous call towards gender response to learning of science specifically, Biology by stakeholders. National trends revealed mixed result with regard to the gender gap in science retention. This is because it appears that there is still a considerable bias against female students which impedes their retention (Ingels & Dalton, 2016). The influence of gender in learning Biology has been of great concern to science educators for a long time, yet no consistent result has emerged. Garcia and Lopez (2018) indicated that male and female students showed similar improvements in academic retention. Gender was not found to be a significant factor in the differences. On the contrary, Garcia and Lopez (2018) found that boys achieve better academically than girls. However, with the contradictions and lack of a clear trend in the gender of students towards Biology, more investigation is imperative. The issue of gender and gender stereotyping permeate all aspects of human endeavours (Umanah & Sunday, 2022). Gender difference has been a long debate issue in educational research but with conflicting results. The inconsistent results of gender as it impact on the academic retention of Biology students are dependent variables considered germane in this study.

Atabang and Umanah (2024) defined academic retention as the ability of students to retain and apply learned knowledge over time, ensuring long-term understanding and application of concepts. Gomez and Martinez (2019) explored the role of instructional tools in promoting academic retention in Biology education. Their study demonstrated that utilizing interactive learning resources such as science text cards and crossword puzzle helped students consolidate their understanding of Biology concepts, leading to increased retention levels. The factors that influence retention include context dependency and effects on recall (Chen & Wang, 2018; Atabang & Umanah, 2024; Garcia & Lopez, 2018). This suggests that the characteristics of the environment are encoded as an integral part of memory trace which can be used to enhance retrieval of other information in the trace memory, therefore students are expected to recall more when the environment of learning are

exciting especially when it involved the use of active learning approaches like science text cards and crossword puzzle. In this study, gender is considered as a determinant of students' retention when exposed to science text cards and crossword puzzles strategies.

Despite the growing interest in using science text cards and crossword puzzle in Biology education, there is limited research on the specific impact of these instructional approaches on students' academic retention in Biology. Therefore, this study seeks to investigate the effect of science text cards, crossword puzzles on students' academic retention in Biology in south-south region, Akwa Ibom State, Nigeria.

Statement of the Problem

Despite the importance of Biology Education in fostering scientific literacy and understanding of the natural world, many students struggle to achieve academic success and retain key biological concepts. Traditional teaching methods often fail to engage students actively and effectively, leading to poor retention rates (Kim, 2019). This necessitates the exploration of innovative instructional strategies to improve learning outcomes.

While science text cards and crossword puzzles have shown promise as engaging and effective learning tools in other contexts, their impact on students' academic retention specifically within Biology education remains under-researched. There is a lack of empirical evidence to definitely determine the effectiveness of these methods in enhancing students' understanding, and long-term retention of biological concepts (Jones & Peterson, 2018). Furthermore, the potential influence of gender on the effectiveness of these strategies requires further investigation. Hence, this study is undertaken to determine the effect of science text cards, crossword puzzle instructional materials on senior secondary school students' retention in genetics in Biology in south-south region of Akwa Ibom State, Nigeria.

Purpose of the Study

The main purpose of this study is to investigate the effects of science text cards and crossword puzzle on students' academic retention in Biology in south-south region, Akwa Ibom State, Nigeria. Specifically, the objectives of the study seek to:

1. determine the mean retention scores of Biology students' taught the concept of genetics using science text cards, crossword puzzle and those taught without.
2. compare the mean retention scores of male and female Biology students taught the concept of genetics using science text cards, crossword puzzle and those taught without.
3. find out the interaction effect of treatments and gender on the mean retention scores of Biology students' taught the concept of genetics.

Research Questions

The following research questions raised and answered in the course of the study.

1. What difference exist in the mean retention scores of Biology students' taught the concept of genetics using science text cards, crossword puzzle and those taught without?
2. What is the difference in the mean retention scores of male and female Biology students taught the concept of genetics using science text cards, crossword puzzle and those taught without?
3. What is the interaction effect of treatments and gender on the mean retention scores of Biology students' taught the concept of genetics?

Null Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance .

1. There is no significant difference in the mean retention scores of Biology students' taught the concept of genetics using science text cards, crossword puzzle and those taught without.
2. There is no significant difference in the mean retention scores of male and female Biology students taught the concept of genetics using science text cards, crossword puzzle and those taught without.
3. There is no significant interaction effect of treatments and gender on the mean retention scores of Biology students' taught the concept of genetics.

Methodology

This study employed quasi-experimental pretest posttest non-equivalent control group design. This design is chosen because the participants were not randomized hence intact classes was used for data gathering. This study in the context of this design employed two experimental groups and a control group. The study was carried out in the south-south region located at approximately 4.75° North latitude and 8.20° East longitude situated in the southern part of Nigeria, along the coastline of the Atlantic Ocean, Akwa Ibom State, Nigeria. Population of the study consisted of all the 1,423 students with males accounting for 724 and females 699 of Senior Secondary Two (SSII) Biology students during the 2024/2025 academic session. A sample size of One Hundred and Fifty (150) senior secondary II Biology students drawn from three schools in their intact classes through criterion and simple random sampling techniques was used for the study. Genetics Retention Test (GRT) was used to gather data for the study. The items are expected to test students' academic retention. The instrument was duly validated and subjected to reliability analysis using Kuder Richardson 20 ($K - R 20$) formula. The result showed reliability coefficient of 0.82 and was deemed appropriate for the main study. Descriptive

statistics of mean and standard deviation were used in answering the research questions while analysis of covariance (ANCOVA) was used in testing the hypotheses at 0.05 Alpha level. The GRT was administered to students as pretest and posttest. The Biology teachers were recruited and instructed to serve as research assistants on the use of the lesson packages for the experimental groups I and II and the control group. The lesson package for the experimental group I was designed using science text cards instructional material, experimental group II lesson package was based on cross word puzzle instructional material and the control group taught without instructional material. Pretest was administered to students' in the three groups before treatment started. The treatment lasted for two weeks after which the GRT was reshuffled and administered as posttest to students in the three groups. Pretest and Posttest scripts from the three groups were collected, scored and used for data analysis. The research questions were answered using Analysis of Covariance (ANCOVA) at .05 level significance.

Results

Research Question 1: What difference exist in the mean retention scores of Biology students' taught the concept of genetics using science text cards, crossword puzzle and those taught without?

Mean and standard deviation were used to answer research question two and the result is shown in Table 1.

Table 1: Descriptive statistics of mean retention scores of Biology students' taught the concept of genetics using science text cards, crossword puzzle and those taught without instructional materials

Materials	N	Pretest		Posttest		Mean Difference
		Mean	SD	Mean	SD	
science text cards	50	18.20	3.31	40.90	3.20	22.70
crossword puzzle	50	18.24	3.38	24.96	3.65	6.72
Without	50	14.18	4.02	15.18	3.79	1.00

The result in Table 1 shows the difference in the mean retention scores of Biology students' taught the concept of genetics using science text cards, crossword puzzle and those taught without. The result indicates that the pretest-posttest mean difference of 22.70 obtained by the students taught the concept of genetics using science text cards is higher than 6.72 obtained by those taught using the crossword puzzle, which is in turn higher than 1.00 obtained by those taught without. The result also indicates that the pretest and posttest standard deviations of 3.31 and 3.20, 3.38

and 3.65, as well as 4.02 and 3.79 are obtained by the students taught using science text cards, crossword puzzle and those taught without respectively. This means that there is a high difference in the mean retention scores of Biology students' taught the concept of genetics using science text cards, crossword puzzle and those taught without.

Research Question 2: What is the difference in the mean retention scores of male and female Biology students taught the concept of genetics using science text cards, crossword puzzle and those taught without?

Mean and standard deviation were used to answer research question four and the result is shown in Table 2.

Table 2: Descriptive statistics of male and female mean retention scores of Biology students' taught the concept of genetics using science text cards, crossword puzzle and those taught without instructional materials

Gender	Instructional materials	N	Pretest		Posttest		Mean difference
			Mean	SD	Mean	SD	
Male	science text cards	27	18.11	3.81	40.11	3.34	22.00
Female		23	18.30	2.69	41.83	3.05	23.53
Total		50	18.20	2.31	40.90	3.30	22.70
Male	crossword puzzle	21	17.81	2.77	26.10	3.82	8.29
Female		29	18.55	3.79	24.14	3.36	5.59
Total		50	18.24	3.38	24.96	3.65	6.72
Male	Without	24	16.83	3.80	17.88	2.95	1.05
Female		26	11.73	2.32	12.69	2.60	0.96
Total		50	14.18	4.02	15.18	3.79	1.00

The result in Table 2 indicates the mean retention scores of male and female Biology students taught the concept of genetics using science text cards, crossword puzzle and those taught without. The result indicates that the pretest-posttest mean retention difference of male and female students taught genetics using science text cards is 22.70; that of crossword puzzle is 6.72, while that of without is 1.00. The values indicate that great difference exists in the mean retention scores of male and female Biology students taught the concept of genetics using science text cards, crossword puzzle and those taught without.

Research Question 3: What is the interaction effect of treatments and gender on the mean retention scores of Biology students' taught the concept of genetics?

Mean and standard deviation were used to answer research question six and the result is shown in Table 3.

Table 3: Descriptive statistics of the interaction effects of treatments and gender on students' pretest posttest mean retention scores of the concept of genetics in Biology

Instructional materials	Gender	N	Pretest		Posttest		Mean difference
			Mean	SD	Mean	SD	
science text cards	Male	27	18.11	3.81	40.11	3.34	22.00
	Female	23	18.30	2.69	41.83	3.05	23.53
	Total	50	18.20	2.31	40.90	3.30	22.70
crossword puzzle	Male	21	17.81	2.77	26.10	3.82	8.29
	Female	29	18.55	3.79	24.14	3.36	5.59
	Total	50	18.24	3.38	24.96	3.65	6.72
Without	Male	24	16.83	3.80	17.88	2.95	1.05
	Female	26	11.73	2.32	12.69	2.60	0.96
	Total	50	14.18	4.02	15.18	3.79	1.00

The result in Table 3 indicates the interaction effect of treatments and gender on the mean retention scores of Biology students' taught the concept of genetics. The result indicates that the pretest-posttest mean retention difference of male and female students taught genetics using science text cards is 22.70; that of crossword puzzle is 6.72, while that of without is 1.00. The results indicate great interaction effect of treatments and gender on the mean retention scores of Biology students' taught the concept of genetics.

Null Hypothesis 2: There is no significant difference in the mean retention scores of Biology students' taught the concept of genetics using science text cards, crossword puzzle and those taught without.

In order to test hypothesis two, analysis of covariance was employed and the result is shown in Table 4.

Table 4: Summary of analysis of variance of the difference in the mean retention scores of Biology students' taught the concept of genetics using science text cards, crossword puzzle and those taught without

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	17007.360 ^a	3	5669.120	476.064	.000
Intercept	3132.774	1	3132.774	263.075	.000
Pretest Retention	153.187	1	153.187	12.864	.600
Instructional materials	13520.867	2	6760.434	567.707	.000
Error	1738.613	146	11.908		
Total	128204.000	150			
Corrected Total	18745.973	149			

The result in Table 4 indicates that the F-value of 567.707 with 2 and 146 degrees of freedom at .05 alpha level is significant since the p-value of .000 is lower than the alpha value of .05. The null hypothesis is rejected, which means that there is significant difference in the mean retention scores of Biology students' taught the concept of genetics using science text cards, crossword puzzle and those taught without.

Null Hypothesis 2: There is no significant difference in the mean retention scores of male and female Biology students taught the concept of genetics using science text cards, crossword puzzle and those taught without.

In order to test hypothesis four, analysis of covariance was employed and the result is shown in Table 5.

Table 5: Summary of analysis of variance of the difference in the mean retention scores of male and female Biology students' taught the concept of genetics using science text cards, crossword puzzle and those taught without

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	17304.077 ^a	6	2884.013	286.022	.000
Intercept	3215.656	1	3215.656	318.912	.000
Pretest Retention	31.496	1	31.496	3.124	.079
Instructional materials	13614.448	2	6807.224	675.106	.000
Gender	91.966	1	91.966	9.121	.003
Instructional materials * Gender	219.836	2	109.918	10.901	.000
Error	1441.897	143	10.083		
Total	128204.000	150			

Corrected Total 18745.973 149

The result in Table 5 indicates that the F-value of 10.901 with 2 and 143 degrees of freedom at .05 alpha level is significant since the p-value of .000 is lower than the alpha value of .05. The null hypothesis is rejected, which means that there is significant difference in the mean retention scores of male and female Biology students taught the concept of genetics using science text cards, crossword puzzle and those taught without.

Null Hypothesis 3: There is no significant interaction effect of treatments and gender on the mean retention scores of Biology students' taught the concept of genetics. In order to test hypothesis five, analysis of covariance was employed and the result is shown in Table 6.

Table 6: Summary of analysis of variance of interaction effect of treatments and gender on the mean retention scores of Biology students' taught the concept of genetics.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	17304.077 ^a	6	2884.013	286.022	.000
Intercept	3215.656	1	3215.656	318.912	.000
Pretest Retention	31.496	1	31.496	3.124	.079
Instructional materials	13614.448	2	6807.224	675.106	.000
Gender	91.966	1	91.966	9.121	.003
Instructional materials * Gender	219.836	2	109.918	10.901	.000
Error	1441.897	143	10.083		
Total	128204.000	150			
Corrected Total	18745.973	149			

The result in Table 6 indicates that the F-value of 10.901 with 2 and 143 degrees of freedom at .05 alpha level is significant since the p-value of .000 is lower than the alpha value of .05. The null hypothesis is rejected, which means that there is significant interaction effect of treatments and gender on the mean retention scores of Biology students' taught the concept of genetics.

Summary of Findings

1. There is significant difference in the mean retention scores of Biology students' taught the concept of genetics using science text cards, crossword puzzle and those taught without. Within the experimental groups, students' taught with science text cards retained better than their counterpart groups

2. There is significant difference in the mean retention scores of male and female Biology students taught the concept of genetics using science text cards, crossword puzzle and those taught without.
3. There is significant interaction effect of treatments and gender on the mean retention scores of Biology students' taught the concept of genetics.

Discussion of Findings

From the data analyses done, the discussion of findings is carried out in this sub-section.

Science text card, crossword puzzle and those taught without instructional material on their academic retention

The result of hypothesis one indicated that science text card, crossword puzzle significantly influence students' academic retention than those taught without instructional materials in the concept of genetics in Biology. The retention of knowledge is critical in the learning process, particularly in subjects that require cumulative knowledge like Biology. This study is supported by the work of Carter et al., (2019) indicated that students who utilize science text cards and engage in crossword puzzle exhibit significantly better retention rates compared to their peers who learn without these materials and also demonstrated that students using science text cards for vocabulary and concept reinforcement retained information for longer periods, with a retention rate increase of 30% over traditional approach.

Additionally, this study is in agreement by the work of Allen and Martinez (2020) highlights that science text cards and crossword puzzles not only aid in recall but also enhance the ability to apply knowledge in new contexts and students who frequently practiced with crosswords showed improved long-term retention of biological concepts, as the puzzles encouraged them to actively engage with the content. In contrast, students who were taught without these instructional materials often faced challenges in retaining information, leading to a decline in performance over time. By incorporating instructional materials such as science text cards and crossword puzzles, teachers can create a more dynamic learning experience that not only enhances academic achievement but also fosters better retention of information.

Effect of gender on science text card, crossword puzzle instructional materials and students' academic retention

The result of analysis two indicated that male and female students' in the experimental groups taught the concept of genetics based on science text card, crossword puzzle significantly influence students' academic retention than those taught without instructional materials in the concept of respiratory system in Biology. The impact of gender on students' retention of information when using instructional materials such as science text cards and crossword puzzles has been a significant area

of research. This study is in contrast by the works of Green and White (2019) found that male students retained information better when engaged with crossword puzzles, which encouraged active participation and critical thinking. This active engagement is essential for retention, as it allows students to apply and manipulate knowledge in ways that reinforce learning.

On the other hand, female students exhibited higher retention rates when utilizing science text cards. This study is in line by the works of Adams and Lee (2023), the structured nature of science text cards helped female students organize information effectively, leading to improved retention. The study indicated that the visual and concise presentation of information in science text cards played a crucial role in aiding memory retention for female students, who often benefit from organized and systematic learning approaches. These findings underscore the importance of recognizing gender-specific preferences in instructional materials to enhance retention rates in Biology. Employing a combination of both instructional materials may provide a balanced approach that caters to the diverse needs of students, thereby improving retention across genders.

Interaction effect of treatments and gender on academic retention

The result of the analysis three indicated that the interaction effect of treatment and gender significantly influence students' academic retention in the concept of genetics in Biology. The interaction between instructional treatments and gender also plays a critical role in students' retention of knowledge in Biology. This study is in agreement by the works of Smith and Johnson (2019) examined how science text cards and crossword puzzles affected knowledge retention among male and female students. The results indicated that there was a significant interaction effect; retention rates varied based on the combination of instructional approach and gender.

For instance, male students who engaged with crossword puzzles demonstrated higher retention rates compared to their female counterparts. The competitive and interactive nature of crossword puzzles seemed to resonate more with male learners, enhancing their ability to recall information. On the other hand, female students exhibited superior retention when using science text cards, which provided a structured format that facilitated better organization and comprehension of material. These findings suggest that instructional approaches should be gender-responsive, taking into account how different instructional materials can affect knowledge retention. Incorporating a mix of instructional materials may benefit all students by catering to diverse learning preferences and enhancing retention across genders.

Conclusion

From the findings, it can be concluded that students' taught using instructional material based on science text cards and crossword puzzle lead to better

academic retention on the part of the students. Also, the interaction effects of gender and treatment have a significant effect on students' academic retention.

Recommendations

1. Students' should actively engage with instructional materials like science text cards and crossword puzzles to enhance their understanding and retention of biological concepts. They are encouraged to participate in collaborative learning activities that utilize these tools to promote deeper learning.
2. Teachers should integrate various instructional materials, including science text cards and crossword puzzles, into their lesson plans to cater to different learning styles and preferences. This can enhance student engagement and promote better academic retention outcome.
3. Educational authorities should consider incorporating the use of science text cards and crossword puzzles into the curriculum for Biology. This can help standardize effective instructional practices across schools.

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