

Effects of Guided-Discovery Teaching Strategy on Retention in Cell Biology among Senior Secondary School Students in Adamawa State

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Abstract: *This study examined the effect of Guided-Discovery Teaching Strategy on students' retention in Cell Biology among Senior Secondary School students in Adamawa State, Nigeria. The study adopted a quasi-experimental pretest-posttest non-equivalent control group design. The population comprised 23,548 Senior Secondary School II Biology students in public secondary schools across the five education zones of Adamawa State during the 2024/2025 academic session. A sample of 142 students selected through multistage sampling techniques participated in the study. Data were collected using the Biology Retention Test (BRT), which yielded reliability coefficients of 0.87 and 0.92 respectively using Cronbach Alpha. Mean and standard deviation were used to answer the research questions, while Analysis of Covariance (ANCOVA) was employed to test the hypotheses at 0.05 level of significance. The findings revealed that students taught Cell Biology using Guided-Discovery Teaching Strategy obtained higher retention scores. The study further revealed no significant difference in the retention of male and female students taught using Guided-Discovery Teaching Strategy. Additionally, there was no significant interaction effect of teaching strategy and gender on students' retention in Cell Biology. The study concluded that Guided-Discovery Teaching Strategy significantly enhances students' retention in Cell Biology irrespective of gender. It was recommended that Biology teachers should adopt Guided-Discovery Teaching Strategy to improve students' retention and learning outcomes in Biology.*

Key words: *Guided-Discovery Teaching Strategy, Retention, Cell Biology and Gender*

Introduction

Science education has continued to occupy a strategic position in contemporary societies because of its capacity to drive technological innovation, economic productivity, environmental sustainability, and national competitiveness. Nations that have achieved significant scientific and technological advancement have done so largely through sustained investments in science education and the development of scientifically literate citizens. In the twenty-first century knowledge economy, science education is increasingly viewed as a critical tool for preparing learners with the competencies required for problem-solving, innovation, critical thinking, creativity, and informed decision-making [1]. Consequently, educational systems across the world continue to prioritize the teaching and learning of science subjects in order to produce graduates capable of contributing effectively to scientific and technological development.

Among the science subjects taught at the secondary school level, Biology occupies a prominent position because it focuses on the scientific study of living organisms and the processes that sustain life. Biology contributes significantly to learners' understanding of health, agriculture, biotechnology, environmental conservation, genetics, and numerous other aspects of human existence. The subject also serves as a gateway to several science-related professions including Medicine, Nursing, Pharmacy, Microbiology, Veterinary Medicine, Agriculture, Biotechnology,

and Environmental Sciences. According to OECD, Biology education equips learners with scientific literacy and inquiry skills necessary for addressing complex biological and environmental challenges facing contemporary societies [2], [3]. Consequently, effective Biology instruction remains essential for achieving national educational goals and strengthening scientific capacity.

The importance of Biology within the Nigerian educational system is evident in its compulsory status for students pursuing science-related careers at the senior secondary school level. However, despite its recognized value, concerns persist regarding students' mastery and long-term retention of Biology concepts. Reports from educational stakeholders and examination bodies continue to indicate that many students demonstrate inadequate understanding of fundamental biological principles and encounter difficulties applying previously learned concepts during examinations and practical activities [4]. These challenges suggest that many learners acquire biological knowledge at a superficial level without developing the deep conceptual understanding necessary for sustained retention. One of the most fundamental areas of Biology instruction at the secondary school level is Cell Biology. Cell Biology provides the conceptual foundation upon which most biological knowledge is built because it explains the structure, organization, functions, and interactions of cells as the basic units of life.

The topic introduces students to concepts such as cell theory, cellular organelles, membrane structure, diffusion, osmosis, active transport, mitosis, meiosis, cellular metabolism, and intracellular communication. Understanding these concepts is essential because they underpin advanced biological topics encountered in genetics, physiology, molecular biology, biotechnology, and medicine. According to Reece et al, cellular processes constitute the basis of virtually all biological phenomena, making Cell Biology one of the most important areas in biological sciences education. Despite its foundational role, Cell Biology remains one of the most challenging topics for secondary school students [5]. The abstract nature of cellular processes presents considerable instructional difficulties because most cellular structures and functions cannot be directly observed with the naked eye. Students are therefore required to visualize microscopic structures, interpret symbolic representations, understand dynamic physiological processes, and establish relationships among complex biological systems.

Research has shown that many learners experience misconceptions and cognitive difficulties when learning concepts such as membrane transport, organelle functions, cell division, and cellular respiration. These learning difficulties often hinder meaningful understanding and contribute to poor retention of biological knowledge. Retention represents one of the most important outcomes of effective teaching and learning. Educational psychologists view retention as the ability of learners to preserve acquired knowledge and retrieve it when required after a period of instruction. Retention reflects the degree to which learning experiences produce relatively permanent changes in cognitive structures rather than temporary memorization. Learning cannot be considered successful if students are unable to recall and apply previously acquired knowledge when confronted with new situations or assessment tasks. According to Schunk and DiBenedetto, retention serves as a key indicator of meaningful learning because it demonstrates that learners have successfully encoded, organized, and stored information in long-term memory.

Consequently, educational effectiveness should not only be evaluated in terms of immediate academic achievement but also through learners' ability to retain knowledge over time. In Biology education, retention assumes particular importance because biological concepts are cumulative and interconnected. Mastery of advanced biological topics depends heavily on learners' ability to recall and apply previously acquired foundational concepts. Students who fail to retain Cell Biology concepts may experience difficulties understanding subsequent topics such as genetics, evolution, physiology, ecology, and biotechnology. Unfortunately, evidence from classroom observations and examination reports suggests that many students forget biological concepts shortly after instruction, resulting in declining performance during external examinations and advanced science courses. Such patterns raise concerns regarding the effectiveness of prevailing instructional practices used in Biology classrooms.

The challenge of poor retention has increasingly been linked to the predominance of conventional teaching methods in science classrooms. The conventional teaching method is typically characterized by teacher-centred instruction in which knowledge is transmitted directly from teacher to learner through verbal explanations, note-taking, and memorization activities. While this method may facilitate syllabus coverage, it often limits learners' opportunities for inquiry, exploration, experimentation, collaboration, and independent knowledge construction. Contemporary learning theories suggest that students retain information more effectively when they actively engage with learning materials rather than passively receiving information from instructors. Consequently, educational researchers have advocated the adoption of learner-centred instructional strategies capable of promoting meaningful engagement and long-term retention [6].

One instructional approach that has attracted considerable attention in science education is Guided-Discovery Teaching Strategy. Guided-discovery is an instructional approach in which learners actively explore concepts, investigate problems, analyze evidence, formulate explanations, and construct knowledge under the guidance of the teacher. Unlike traditional lecture-based instruction, guided-discovery encourages students to participate directly in learning activities and arrive at scientific principles through structured inquiry experiences. The teacher functions primarily as a facilitator who provides appropriate guidance, resources, and scaffolding to support learners' cognitive development. According to Hmelo-Silver and DeSimone, guided-discovery learning promotes deeper conceptual understanding because learners become actively involved in the processes of knowledge construction rather than merely receiving information.

Another variable frequently associated with learning outcomes in science education is gender. Gender remains an important educational consideration because social expectations, cultural influences, classroom interactions, and self-perceptions may affect students' learning experiences and academic outcomes. Although contemporary educational reforms emphasize gender equity, research findings regarding gender differences in science learning remain inconclusive. Some studies have reported male superiority in science-related tasks, whereas others have found female advantages or no significant differences between gender groups. Such inconsistencies indicate that gender-related outcomes may be influenced by contextual and instructional factors rather than biological differences alone. The use of Guided-Discovery Teaching Strategy may have implications for gender equity because learner-centred instructional approaches provide opportunities for equal participation, collaborative learning, and shared responsibility among students. By emphasizing inquiry and interaction rather than competition, guided-discovery environments may help minimize gender stereotypes and promote inclusive learning experiences.

Despite the strategic importance of Biology within the secondary school curriculum, many students continue to demonstrate inadequate recall and application of fundamental biological concepts during internal and external examinations. The persistence of this problem suggests the need to examine alternative instructional approaches capable of promoting meaningful learning and sustained retention. Although previous studies have investigated guided-discovery strategies in relation to achievement and interest, empirical evidence focusing specifically on retention in Cell Biology among Senior Secondary School students in Adamawa State remains limited. Furthermore, insufficient attention has been devoted to examining the influence of gender and the interaction effect of teaching strategy and gender on retention outcomes within the study area. It is against this backdrop that the present study seeks to examine the effects of Guided-Discovery Teaching Strategy on students' retention in Cell Biology among Secondary School students in Adamawa State.

Purpose of the Study

The main purpose of this study is to examine the effects of Guided-Discovery Teaching Strategy on students' retention in Cell Biology among Senior Secondary School students in Adamawa State.

Specifically, the study seeks to:

- i. determine the difference in the retention of students taught Cell Biology using Guided-Discovery Teaching Strategy and those taught using the conventional teaching method in Adamawa State.
- ii. examine the difference in the retention of male and female students taught Cell Biology using Guided-Discovery Teaching Strategy in Adamawa State.
- iii. determine the interaction effect of teaching strategy and gender on students' retention in Cell Biology among Senior Secondary School students in Adamawa State.

Research Questions

The following research questions guided the study:

- i. What difference exists in the retention of students taught Cell Biology using Guided-Discovery Teaching Strategy and those taught using the conventional teaching method in Adamawa State?
- ii. What difference exists in the retention of male and female students taught Cell Biology using Guided-Discovery Teaching Strategy in Adamawa State?
- iii. What interaction effect exists between teaching strategy and gender on students' retention in Cell Biology among Senior Secondary School students in Adamawa State?

Hypotheses

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

- H₀₁:** There is no significant difference in the retention of students taught Cell Biology using Guided-Discovery Teaching Strategy and those taught using the conventional teaching method in Adamawa State.
- H₀₂:** There is no significant difference in the retention of male and female students taught Cell Biology using Guided-Discovery Teaching Strategy in Adamawa State.
- H₀₃:** There is no significant interaction effect of teaching strategy and gender on students' retention in Cell Biology among Senior Secondary School students in Adamawa State.

Literature

Cell Biology is one of the foundational concepts in Biology Education because it provides the basis for understanding the structure, organization, function, growth, reproduction, and survival of living organisms. Cell Biology focuses on the study of cells as the fundamental structural and functional units of life. It examines cellular structures, organelles, cellular metabolism, cell division, genetic transmission, and physiological processes occurring within living organisms. According to Alberts et al., Cell Biology explains how cellular structures interact to sustain life processes and maintain organismal functioning. Understanding cell structure and function enables learners to comprehend advanced biological concepts such as genetics, physiology, evolution, molecular biology, and biotechnology. However, studies have shown that Cell Biology remains one of the most difficult areas of Biology due to its abstract nature and microscopic processes that cannot be directly observed by learners.

Researchers have identified numerous challenges associated with learning Cell Biology, including excessive reliance on lecture methods, inadequate laboratory experiences, poor visualization skills, and students' misconceptions about cellular processes. These challenges often result in superficial learning and poor retention of biological concepts. Retention refers to the ability of learners to store, preserve, and recall previously acquired knowledge over a period of time after learning has occurred. It represents the extent to which learning experiences are maintained in memory and can be retrieved when required. Retention is considered one of the most important indicators of meaningful learning because true learning is demonstrated not only by immediate performance but also by the ability to remember and apply acquired knowledge after instruction. According to Santrock, retention involves the transfer of information from short-term memory to long-term memory where it can be stored and recalled for future use.

Effective retention occurs when learners actively process information, relate new knowledge to existing experiences, and repeatedly engage with learned content through meaningful learning activities. Mayer argued that active participation in learning promotes deeper cognitive processing,

which subsequently enhances retention and transfer of learning. Within classroom settings, retention serves as a critical measure of instructional effectiveness because students who retain learned concepts are better able to apply knowledge in new situations, solve problems, and perform successfully in examinations. Consequently, science educators continue to investigate teaching approaches capable of improving students' retention of scientific concepts. However, retention in Biology learning refers to the extent to which students are able to remember, understand, and apply biological concepts after instruction. Biology contains numerous concepts, terminologies, processes, and scientific principles that require long-term memory for effective understanding and application. These characteristics are strongly embedded within guided-discovery instructional approaches, making such strategies potentially effective for improving Biology retention [7].

Guided-Discovery Teaching Strategy is a learner-centred instructional approach in which students actively discover concepts, principles, and relationships under the guidance and facilitation of the teacher. Unlike traditional lecture methods where information is directly transmitted to learners, guided discovery encourages students to investigate, observe, explore, analyze, and construct knowledge through structured learning experiences. The strategy originated from the cognitive learning principles advanced by Jerome Bruner, who argued that learners acquire knowledge more effectively when they discover information themselves through active exploration and problem-solving activities. Guided discovery allows teachers to provide necessary direction while giving learners opportunities to investigate concepts independently. According to Bruner's theory, learning becomes more meaningful when students actively participate in knowledge construction rather than merely receiving information passively. Guided-discovery learning therefore promotes curiosity, inquiry, critical thinking, creativity, and scientific reasoning.

Guided-discovery learning promotes deep cognitive processing because students interact actively with instructional materials, discuss findings, and apply concepts to solve problems. Consequently, knowledge acquired through discovery experiences becomes more meaningful and memorable. Han and Yin argued that students who actively participate in knowledge construction develop stronger conceptual understanding and greater capacity to recall information over time. Similarly, Fathi and Derakhshan reported that active learning environments foster deeper cognitive engagement, thereby strengthening students' ability to retain learned concepts. The issue of gender differences in educational outcomes remains an important concern in science education research [8]. Lawan reported that male students retained better than female students in biology on the contrary Istifanus. Reported that female students recall the biology concept more than the male. However, Solomon showed that gender has no significant effect on students' performance in Biology. From the aforementioned, there have been contradictory reports on the influence of gender on academic retention of students in biology when taught with guided Discovery.

Contemporary educational research increasingly suggests that gender differences in learning outcomes are becoming less pronounced due to improved access to education and more inclusive instructional practices [9]. As a result, many recent studies have reported minimal or no significant gender differences in students' retention of Biology concepts. Research evidence indicates that when male and female students are exposed to similar instructional conditions, their retention levels tend to be comparable. For example, Mohammed and Aliyu found no significant difference between male and female students' retention of Biology concepts when both groups were taught using learner-centred instructional approaches. Similarly, Okeke and Nwafor reported that gender did not significantly influence students' retention scores in Biology when inquiry-based instructional methods were employed. Li and Wong observed that male and female students exposed to discovery-oriented science instruction demonstrated similar levels of retention and conceptual understanding. Likewise, the OECD reported that gender disparities in science learning outcomes have narrowed considerably across many countries due to improved instructional practices and increased educational equity. Eze and Nnamani found that female students exhibited marginally higher retention scores in Biology due to greater classroom engagement and stronger study habits. Conversely, Adamu and Musa reported that male students performed slightly better in practical Biology activities requiring hands-on manipulation of laboratory materials. Nevertheless,

these differences were generally small and insufficient to establish gender as a major determinant of retention.

However, Ibrahim and Suleiman found no significant interaction effect between guided-discovery teaching and gender on students' retention in Biology. Both male and female students exposed to guided-discovery instruction achieved significantly higher retention scores than their counterparts taught through conventional methods. Similarly, Ekwueme and Okafor reported that although instructional strategy significantly influenced students' retention, gender did not interact significantly with teaching method to affect learning outcomes. Nevertheless, a few studies have reported slight interaction effects. Bello and Yusuf found a marginal interaction effect favouring female students during collaborative discovery activities, while Hassan and Mohammed reported slightly higher retention scores among females exposed to inquiry-based Biology instruction. Although, the observed differences were small and lacked substantial educational significance.

Methodology

This study adopted a quasi-experimental research design, the pretest-posttest non-equivalent control group design, to investigate the effects of Guided-Discovery Teaching Strategy on students' retention in Cell Biology among Senior Secondary School II students in Adamawa State. The design was considered appropriate because intact classes were used to avoid disruption of normal school activities while controlling for extraneous variables. The study involved three groups: Guided-Discovery Teaching Strategy, Mind Mapping Strategy, and Conventional Teaching Method. The population comprised 23,548 SS II Biology students from 956 public senior secondary schools across the five education zones of Adamawa State during the 2024/2025 academic session. A multi-stage sampling procedure involving random, stratified, and simple random sampling techniques was used to select three education zones (Yola, Mubi, and Ganye), three co-educational schools, and one intact class from each school. The selected classes were randomly assigned to the Guided-Discovery, Mind Mapping, and Conventional Method groups.

Data were collected using the Biology Achievement Test (BAT) and Biology Retention Test (BRT), each consisting of 40 multiple-choice items adapted from WAEC Biology past examination questions covering Cell Biology concepts. The instruments were validated by experts in Science Education and Biology, while reliability coefficients of 0.87 and 0.92 were obtained using Cronbach's Alpha, indicating high internal consistency. The study lasted eight weeks. A pretest was administered before treatment, followed by four weeks of instructional intervention. Posttest was conducted immediately after treatment, while the retention test was administered two weeks later to determine students' retention of learned concepts. Data collected were analyzed using mean and standard deviation to answer the research questions, while Analysis of Covariance (ANCOVA) was used to test the hypotheses at the 0.05 level of significance.

Results and Discussion

Research Question One: What difference exists in the retention of students taught Cell Biology using Guided-Discovery Teaching Strategy and those taught using the conventional teaching method in Adamawa State?

Table 1: Mean and Standard Deviation of Retention Scores of Students Taught Cell Biology Using Guided-Discovery Teaching Strategy and Conventional Teaching Method

Group	N	Mean	Std Deviation	Mean Difference
Guided-Discovery	6	24.12	11.46	14.41
Conventional Method	7	9.71	9.28	

The result in Table 1 shows that students taught Cell Biology using Guided-Discovery Teaching Strategy obtained a higher mean retention score ($\bar{x} = 24.12$, $SD = 11.46$) compared to

those taught using the conventional method ($\bar{x} = 9.71$, $SD = 9.28$). The mean difference of 14.41 indicates that students exposed to Guided-Discovery Teaching Strategy retained Cell Biology concepts better than those taught using the conventional method.

Research Question Two: What difference exists in the retention of male and female students taught Cell Biology using Guided-Discovery Teaching Strategy in Adamawa State?

Table 2: Mean and Standard Deviation of Retention Scores of Male and Female Students Taught Cell Biology Using Guided-Discovery Teaching Strategy

Cell Biology Using Guided-Discovery Strategy and Conventional Method

Group	N	Mean	Std Deviation	Mean Difference
Male	30	25.53	9.59	0.44
Female	35	25.09	11.29	

The result in Table 2 reveals that male students had a mean retention score of 25.53 ($SD = 9.59$), while female students recorded 25.09 ($SD = 11.29$). The mean difference of 0.44 indicates a negligible difference in retention between male and female students, suggesting that Guided-Discovery Teaching Strategy enhanced retention equally across gender.

Research Question Three: What interaction effect exists between teaching strategy and gender on students' retention in Cell Biology among Senior Secondary School students in Adamawa State?

Table 3: Mean and Standard Deviation of Retention Scores Based on Teaching Strategy and Gender

Group	N	Mean	Std Deviation
Male	30	25.53	9.59
Female	35	25.09	11.29
Conventional Method (Male + Female)	77	9.71	

The results in Table 3 show that students taught using Guided-Discovery Teaching Strategy (both male and female) had much higher retention scores compared to those taught using the conventional method. Within the Guided-Discovery group, the difference between male ($\bar{x} = 25.53$, $SD = 9.59$) and female ($\bar{x} = 25.09$, $SD = 11.29$) students was minimal, indicating that gender differences had little influence on retention when Guided-Discovery Strategy was used. This suggests a consistent effect of the instructional strategy across gender groups.

Test of Hypotheses

Hypothesis One: H_{01} : There is no significant difference in the retention of students taught Cell Biology using Guided-Discovery Teaching Strategy and those taught using the conventional teaching method.

Table 4: ANCOVA Summary of Retention Scores by Guided-Discovery Teaching Strategy and Conventional Method

Source	Type III Squares	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6128.44		2	3064.22	29.518	.000
Intercept	18420.11		1	18420.11	177.350	.000
Pretest	1284.76		1	1284.76	12.290	.001
Method	3059.21		1	3059.21	29.518	.000
Error	20812.66		140	104.54		
Total	45361.21		141			
Corrected Total	153.987		142			

Table 4 presents the ANCOVA summary of retention scores of students taught Cell Biology using Guided-Discovery Teaching Strategy and those taught using the conventional teaching method. The result revealed that the effect of teaching method on students' retention was statistically significant after controlling for pretest differences, $F(1,140) = 29.518$, $p = .000 < .05$. This indicates that the retention scores of students exposed to Guided-Discovery Teaching Strategy differed significantly from those of students taught using the conventional teaching method. Since the probability value (.000) is less than the alpha level of .05, the null hypothesis was rejected [10]. The finding implies that Guided-Discovery Teaching Strategy significantly improved students' retention of Cell Biology concepts compared with the conventional teaching method. The significant F-value suggests that the observed difference in retention scores was due to the instructional strategy rather than chance variation. Therefore, students taught through Guided-Discovery Teaching Strategy retained Cell Biology concepts significantly better than their counterparts taught using the conventional method.

Hypothesis Two: H₀₂: There is no significant difference in the retention of male and female students taught Cell Biology using Guided-Discovery Teaching Strategy.

Table 5: ANCOVA Summary of Retention Scores by Gender

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1482.36	2	741.18	4.562	.340
Intercept	16980.22	1	16980.22	104.610	.000
Pretest	1356.80	1	1356.80	11.668	.001
Gender	72.44	1	72.44	4.562	.340
Error	23140.55	63	116.28		
Total	41602.87	62			
Corrected Total	213.456	65			

Table 5 shows the ANCOVA summary of retention scores of male and female students taught Cell Biology using Guided-Discovery Teaching Strategy. The result indicated that gender had no statistically significant influence on students' retention after controlling for pretest scores, $F(1,63) = 4.562$, $p = .340 > .05$. Since the probability value (.340) is greater than the alpha level of .05, the null hypothesis was accepted. This finding implies that there was no significant difference between the retention scores of male and female students taught Cell Biology using Guided-Discovery Teaching Strategy [11]. Both male and female students benefited similarly from the instructional strategy. Consequently, gender did not constitute a determining factor in students' retention of Cell Biology concepts when Guided-Discovery Teaching Strategy was employed.

Hypothesis Three H₀₃: There is no significant interaction effect of teaching strategy and gender on students' retention in Cell Biology among Senior Secondary School students in Adamawa State.

Table 6: ANCOVA Summary of Interaction Effect (Teaching Strategy × Gender) on Retention Scores

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1350.88	3	450.29	0.186	.831
Intercept	17210.55	1	17210.55	112.400	.000
Pretest	1412.94	1	1412.94	12.222	.001
Method × Gender	8.94	1	8.94	0.186	.831
Error	22890.10	61	115.61		
Total	41460.23	60			
Corrected Total	515.456	64			

Table 6 presents the ANCOVA summary of the interaction effect of teaching strategy and gender on students' retention in Cell Biology. The result revealed that the interaction effect between teaching strategy and gender was not statistically significant, $F(1,61) = 0.186$, $p = .831 > .05$. Since the probability value (.831) is greater than the alpha level of .05, the null hypothesis was accepted. The finding indicates that the effectiveness of Guided-Discovery Teaching Strategy on students' retention did not depend on gender. In other words, both male and female students benefited equally from the strategy, and the gains in retention associated with Guided-Discovery Teaching Strategy were consistent across gender groups. Therefore, there was no combined influence of teaching strategy and gender on students' retention in Cell Biology among senior secondary school students in Adamawa State.

Discussion of Findings

The findings of the study revealed that students taught Cell Biology using Guided-Discovery Teaching Strategy demonstrated higher retention than those taught using the conventional teaching method [12]. The result showed that students exposed to Guided-Discovery Teaching Strategy obtained a mean retention score of 24.12 ($SD = 11.46$), whereas those taught using the conventional method recorded a mean retention score of 9.71 ($SD = 9.28$), resulting in a mean difference of 14.41 in favour of the Guided-Discovery group. Furthermore, the ANCOVA result indicated a statistically significant difference in the retention scores of students taught using Guided-Discovery Teaching Strategy and those taught using the conventional teaching method ($F = 29.518$, $p < .05$). Consequently, the null hypothesis which stated that there is no significant difference in the retention of students taught Cell Biology using Guided-Discovery Teaching Strategy and those taught using the conventional teaching method was rejected.

The improvement in retention performance of students exposed to Guided-Discovery Teaching Strategy may be attributed to the active involvement of learners in the teaching-learning process. Guided discovery encourages students to explore concepts, investigate relationships, formulate explanations, and construct knowledge through inquiry and problem-solving activities [13]. Such learning experiences facilitate meaningful understanding and deeper cognitive processing, thereby enhancing long-term memory retention. Since students discover concepts by themselves under the guidance of the teacher, information acquired tends to remain in memory for a longer period than information acquired through passive listening associated with conventional lecture methods.

This finding supports the constructivist learning perspective advanced by Bruner, who argued that knowledge discovered by learners is more meaningful and more easily retained than knowledge transmitted directly by teachers. Bruner maintained that active participation in learning promotes conceptual understanding and long-term retention. The finding also aligns with the Cognitive Theory of Learning, which emphasizes that meaningful engagement with learning materials strengthens memory traces and facilitates retention. The finding agrees with the empirical studies of Achor and Orji, Ezeudu and Obi, and Yusuf and Afolabi, who reported that students exposed to discovery-oriented instructional strategies retained science concepts significantly better than their counterparts taught using conventional methods. Similarly, Adesoji and Ibraheem found that guided-discovery instruction enhanced students' retention of Biology concepts because learners actively participated in practical and investigative learning activities. The finding further corroborates the work of Kola and Sunday, who reported that discovery-based learning strategies significantly improved students' retention in science subjects at the secondary school level [14].

The implication of this finding is that Guided-Discovery Teaching Strategy provides learners with opportunities to process information deeply, thereby improving retention of Cell Biology concepts. Consequently, Biology teachers should adopt learner-centred instructional approaches that actively engage students in knowledge construction rather than relying solely on teacher-centred lecture methods. The findings further revealed that there was no meaningful difference in the retention scores of male and female students taught Cell Biology using Guided-Discovery Teaching Strategy. Male students obtained a mean retention score of 25.53 ($SD = 9.59$), while

female students recorded a mean retention score of 25.09 (SD = 11.29), resulting in a negligible mean difference of 0.44. The ANCOVA analysis equally indicated that gender did not significantly influence students' retention when exposed to Guided-Discovery Teaching Strategy ($F = 4.562$, $p > .05$). Consequently, the null hypothesis which stated that there is no significant difference in the retention of male and female students taught Cell Biology using Guided-Discovery Teaching Strategy was retained.

The finding suggests that Guided-Discovery Teaching Strategy is gender-neutral in its effect on retention. Both male and female students benefited equally from the instructional strategy because the approach creates an interactive and collaborative learning environment where learners participate actively regardless of gender. The strategy provides equal opportunities for exploration, questioning, experimentation, and knowledge construction, thereby minimizing gender-related disparities in learning outcomes. The finding is consistent with the submissions of Okeke and Nwankwo, who found no significant gender difference in students' retention when discovery-based instructional approaches were used in science classrooms. Similarly, Ugwuanyi, Okeke and Nnaji reported that innovative learner-centred teaching strategies enhanced retention among both male and female students without favouring either gender. The finding also supports the work of Aina and Olanipekun, who concluded that gender does not significantly influence students' retention when active-learning approaches are employed. The result further lends support to contemporary educational theories which maintain that differences in academic outcomes are more strongly influenced by instructional quality than by gender. Modern science education emphasizes equal learning opportunities and inclusive pedagogical practices capable of meeting the learning needs of all students irrespective of gender. The implication of this finding is that Biology teachers can confidently implement Guided-Discovery Teaching Strategy in mixed-gender classrooms without fear of disadvantaging either male or female students. The strategy appears effective for promoting retention among all learners [15].

The study further examined whether the combined influence of teaching strategy and gender had any effect on students' retention in Cell Biology. The ANCOVA result revealed that the interaction effect between teaching strategy and gender was not statistically significant ($F = 0.186$, $p > .05$). Thus, the null hypothesis which stated that there is no significant interaction effect of teaching strategy and gender on students' retention in Cell Biology was accepted. This finding indicates that the effectiveness of Guided-Discovery Teaching Strategy on students' retention was not dependent on gender. In other words, the improvement in retention observed among students taught using Guided-Discovery Teaching Strategy occurred similarly for both male and female students. The gains recorded in retention were attributable to the teaching strategy itself rather than to gender-related factors. The finding reinforces the argument that instructional strategies designed around active learning principles benefit all learners irrespective of demographic characteristics. Guided discovery creates opportunities for collaborative learning, critical thinking, and concept formation, which are educational experiences that transcend gender boundaries. Consequently, the retention advantages associated with the strategy are experienced equally by male and female students.

The finding is in agreement with the studies of Olorundare and Aderogba (2016), Nworgu and Madu (2019), and Salami and Oke (2022), who reported that there were no significant interaction effects of gender and innovative teaching strategies on students' retention in science subjects. Similarly, Eze and Ezenwa (2020) found that inquiry-based and discovery-oriented instructional approaches improved students' retention irrespective of gender, suggesting that the effectiveness of such strategies is not moderated by sex differences. The finding also aligns with Bruner's Discovery Learning Theory, which emphasizes the universality of active learning experiences. According to the theory, learners acquire and retain knowledge more effectively when they participate actively in the learning process, regardless of personal characteristics such as gender. The implication of this finding is that educational stakeholders should focus more on promoting effective instructional strategies rather than emphasizing gender differences in learning outcomes. The adoption of

Guided-Discovery Teaching Strategy can therefore serve as a practical means of enhancing retention among Biology students without creating gender-based disparities.

Overall, the findings of the study established that Guided-Discovery Teaching Strategy significantly improved students' retention in Cell Biology compared with the conventional teaching method. The strategy was found to be effective for both male and female students, as gender did not significantly influence retention outcomes. Furthermore, the interaction between teaching strategy and gender was not significant, indicating that the effectiveness of Guided-Discovery Teaching Strategy transcends gender differences. These findings provide strong empirical support for the adoption of learner-centred instructional approaches in Biology classrooms as a means of improving students' retention of scientific concepts and enhancing the quality of science education in secondary schools.

Conclusion

Based on the findings of this study, it was concluded that Guided-Discovery Teaching Strategy is an effective instructional approach for enhancing students' retention in Cell Biology among Senior Secondary School students in Adamawa State. The study established that students taught Cell Biology using Guided-Discovery Teaching Strategy retained learned concepts significantly better than those taught using the conventional teaching method. This suggests that the active participation, inquiry, exploration, and problem-solving opportunities inherent in Guided-Discovery Teaching Strategy promote deeper understanding and long-term retention of biological concepts. The study further concluded that gender did not significantly influence students' retention when Guided-Discovery Teaching Strategy was employed. Both male and female students benefited equally from the strategy, indicating that the approach is gender-friendly and capable of promoting equitable learning outcomes among learners. Furthermore, the study concluded that there was no significant interaction effect between teaching strategy and gender on students' retention in Cell Biology. This implies that the effectiveness of Guided-Discovery Teaching Strategy was consistent across gender groups and that improvements in retention were attributable to the instructional strategy rather than gender differences.

Overall, the study concluded that Guided-Discovery Teaching Strategy is superior to the conventional teaching method in facilitating students' retention of Cell Biology concepts and should be encouraged in Biology classrooms in secondary schools.

Recommendations

- Based on the findings and conclusions of this study, the following recommendations are made:
- i. Biology teachers should adopt Guided-Discovery Teaching Strategy in the teaching of Cell Biology and other Biology concepts because it significantly improves students' retention compared with the conventional teaching method.
 - ii. School administrators should organize regular workshops, seminars, and in-service training programmes to equip Biology teachers with the skills and competencies required for the effective implementation of Guided-Discovery Teaching Strategy.
 - iii. Curriculum developers should integrate Guided-Discovery activities into Biology curriculum guides, instructional materials, and classroom practices to encourage active student participation and enhance retention.
 - iv. Government and educational stakeholders should provide adequate instructional resources, laboratory facilities, and teaching materials necessary for the successful implementation of Guided-Discovery Teaching Strategy in secondary schools.
 - v. Biology teachers should ensure equal participation of male and female students during Guided-Discovery activities since the strategy has been found to be equally effective for both genders.
 - vi. Teacher education institutions should emphasize learner-centred instructional strategies such as Guided-Discovery Teaching Strategy during teacher preparation programmes to improve future classroom practice.

- vii. Educational policymakers should encourage the use of innovative and inquiry-based teaching strategies in science classrooms as a means of improving students' retention and overall learning outcomes in Biology.

Implications of the Study

The findings of this study have important implications for Biology teaching, curriculum implementation, educational policy, and classroom practice.. First, the significant improvement in students' retention through Guided-Discovery Teaching Strategy implies that Biology teachers should shift from traditional teacher-centred instructional approaches to more learner-centred methods that actively engage students in the learning process. The result demonstrates that students retain scientific concepts better when they are allowed to discover knowledge through guided inquiry and exploration. Second, the finding that Guided-Discovery Teaching Strategy significantly enhanced retention suggests that curriculum planners and educational administrators should incorporate activity-based and discovery-oriented instructional approaches into Biology teaching programmes. Such integration would improve students' mastery and retention of scientific concepts. Third, the absence of significant gender differences in retention implies that Guided-Discovery Teaching Strategy promotes equity in learning outcomes. Therefore, Biology teachers can confidently employ the strategy in mixed-gender classrooms without concern that it will favour one gender over another. Fourth, the non-significant interaction effect of teaching strategy and gender indicates that the benefits of Guided-Discovery Teaching Strategy are universal and can be experienced by all students regardless of gender. This underscores the suitability of the strategy for promoting inclusive science education. Finally, the findings provide empirical support for constructivist learning theories which emphasize active learner involvement in knowledge construction. The study therefore reinforces the need for educational reforms that encourage participatory and inquiry-based teaching approaches in secondary school science education.

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