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EFFECTS OF GUIDED DISCOVERY AND PROBLEM-SOLVING INSTRUCTIONAL STRATEGIES ON ACHIEVEMENT AND RETENTION OF BIOLOGY STUDENTS IN DELTA CENTRAL SENATORIAL DISTRICT, NIGERIA

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Abstract:
This study investigated the effects of guided discovery and problem-solving instructional strategies on the achievement and retention of biology students in Delta Central Senatorial District of Delta State. Ten research questions and ten research hypotheses guided the study. The study adopted the pre-test post-test control group quasi-experimental research design. A sample size of 238 senior secondary school two (SS2) Biology students from six mixed secondary schools in Delta Central Senatorial District was used for the study. The instrument used for data collection was a biology achievement test (BAT) validated by one Biology science educator, an expert in measurement and evaluation and an experienced biology teacher. The reliability of the instrument was established using Kuder Richardson formula 21 which yielded a coefficient of 0.83. Data were collected by administering the BAT as a pre-test, post-test and follow-up test. The data collected were analyzed using mean, standard deviation, paired and independent sample t-test, ANOVA and ANCOVA. The results showed that there was a significant difference in the mean achievement scores in biology among students in guided discovery, problem-solving instructional strategies and lecture method with students in the guided discovery group scoring the highest mark followed by students in problem-solving and lecture method respectively. The result also revealed that there was a significant difference in the mean retention score among students taught with guided discovery, problem-solving instructional strategies and lecture methods. The result further showed that there was no significant interaction effect between teaching methods and sex on achievement and retention. It was recommended that biology teachers should adopt guided discovery and problem-solving instructional strategies in teaching biology concepts. Special training on how to use these teaching

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strategies should be organized for biology teachers to help them effectively implement guided discovery and problem-solving instructional strategies in classroom teaching.

Keywords: guided discovery; problem-solving; instructional strategies; achievement; retention; biology; students

1. Introduction

Biology is one of the science subjects studied at the senior secondary school level in Nigeria. Biology has been defined as the study of living things, the study of life and the study of plants and animals. Ganiyu, Adeboye and Abimbola (2017) see Biology as a unique branch of natural science, however, like other natural sciences it is concerned with the search for an in-depth understanding of natural phenomena and events. Mayer (2004) opined that Biology is composed of two major fields, functional Biology and evolutionary Biology (historical Biology). Functional Biology deals with the physiological process in living things and it can be explained by the natural laws of physical sciences, especially at the cellular molecular level. Functional Biology frequently asks the question "how"? In the field of evolutionary Biology, a sound knowledge of history is needed for the explanation of all aspects of the living world that has to do with the dimension of historical time (Ganiyu, Adeboye & Abimbola, 2017).

Biology is very important in the development of any nation hence the role of Biology in socio-economic development cannot be over-emphasized or hardly needs any arguments. Since it provides insight into how life is created, functions, changes, and responds to environmental stimuli, biology, the study of life, is crucial to human society. It affects nearly every element of a person's daily existence, including their health, ability to reproduce, quality of life, and nutrition. The development and manufacturing of medicine are impacted by biology. It is crucial to human reproduction because it clarifies the procedure and identifies solutions to issues with reproduction (Ifeobu, 2014). Also, it chooses new agricultural breeds and plants that raise the nutritional worth of the country's foods. The environmental elements that endanger human existence are also studied by biology. It develops therapies and researches the causes of infections and disorders. Biology gives tools for environmental management and helps with illness prevention or cure. It results in knowledge that enhances and lengthens life.

Biology is an inherent science subject that provides content in the training to students who want to study medicine, pharmacy, nursing, botany and so on (Ifeobu 2014). Biology has opened many career opportunities for students in medicine, nursing, and food technology among others. For science-related vocational discipline, a credit pass and above in Biology is required. Ifeobu (2014) stated that the majority of senior secondary school students choose biology in WAEC and NECO because they find it to be an interesting subject and a subject that is more related to nature.

According to Ajaja (2009), the main reason for teaching Biology at the secondary school level is to prepare students to acquire:

- Meaningful and relevant knowledge in biology;
- Reasonable and functional scientific attitudes;
- Ability to apply scientific knowledge to everyday life in matters of personal and community health;
- Adequate skills in biology.

Evident in the first reason for teaching Biology at the senior secondary school level, students are required to develop adequate discovery and problem-solving skills in Biology during the teaching and learning process. This skill can only be developed by exposing students to adequate discovery and problem-solving activities in Biology. The exposure of students to guided discovery and problem-solving skills will help in the attainment of the other objectives mentioned above (ability to apply scientific knowledge to everyday life in matters of personal and community health, reasonable and functional scientific attitude, adequate field skills in biology).

Despite the importance of biology, it has been observed that students perform poorly in the subject both in internal and external examinations. Over the years, examination bodies specifically WAEC chief examiners reports (2016, 2017, 2018, 2019), have been reporting the poor performance of students in biology. Students' performances in biology have continued to be poor despite the effort of the government in the provision of instructional materials, conducive learning environment, and regular supervision of teachers. From observation and review of works in literature, the following were identified as the causes of students' poor performance in Biology (I) Biology learning is still dependent on the teacher, the students are not given opportunities to explore their abilities (ii) classroom learning is devoid of the use of students' prior knowledge and this can weaken the necessary information gathering in order for the students to understand a concept. These identified reasons show that the poor performance of students in Biology is caused by teaching methodologies and processes which are not executed properly. This has also affected students' retention of concepts and has reflected in their achievement. It is a well-known fact that the quality of education depends on the teachers and so the method they adopt in teaching matters a lot. The persistent poor performance of students in biology reported yearly in WAEC has shown that lecture instructional strategy influence students' achievement and retention in biology negatively. This shows that the teaching of biology is not properly executed.

For the teaching of Biology to be executed properly, Biology teachers have to adopt the constructivist learning approaches where the learning is not centred on the teacher but on the students using their existing knowledge to solve problems presented to them by their teachers. When this is done, achievement and retention take place. Guided discovery and problem-solving instructional strategies are among the constructivist teaching approaches.

Guided discovery is a teaching technique that encourages students to take a more active role in their learning process by answering a series of questions or solving problems to help them understand a concept (Mayer, 2003). In guided discovery, Bruner 1966 in his theory of discovery learning and cognitive development postulates that a learner is capable of learning any material as long as the instruction is organized appropriately. Guided discovery unlike the lecture method of instruction is student-centred and activity-oriented where the teacher assists students to discover facts about problems and gain experience. Here the teacher presents students with information in a form that requires them to design relationships within the information and to structure and make sense out of it. Learning by discovery will be a powerful method for teaching meaningful information which in turn would have a positive effect on long-term retention.

The key features of guided discovery are:

- A context and frame for student learning through the provision of learning outcomes.
- Learners have responsibility for the exploration of content necessary for understanding through self-directed learning.
- Study guides are used to facilitate and guide self-directed learning.
- Understanding is reinforced through application in problem-oriented; task-based, and work-related experience.

Studies have shown that guided discovery instructional strategies help learning to be organized in a meaningful order such that students on their own and at their own pace can study and acquire knowledge of concepts proceeding from known to unknown (Manttingly, Lutkehaus & Throop, 2008).

Problem-solving instructional strategy is an active learning method (Barrows, 2000). Problem-solving instructional method is a teaching technique which requires students to be responsible for their own learning; students take responsibility for their own learning process. It takes account of learners' interests. Problem-solving instructional strategy helps build up confidence and the ability of students to solve the problems that are characteristics of a rapidly changing society. It fosters the ability of students to identify information that is needed for a particular application, where and how to seek information, how to organize this information into a meaningful conceptual framework and to communicate that information. The feature of the problem-solving instructional strategy is that students integrate new knowledge into what they already know as such it promotes active learning. It fosters self-directed learning, effective problem-solving, communication and collaboration skills.

Studies on problem-solving instructional strategies have demonstrated that students who have learned from problem-based learning or exposed to problem-solving teaching strategies are better able to apply their knowledge to novel problems as well as utilize more effectively self-directed learning strategies than students who have learned

from other teaching methods such as the lecture method (Hmelo & Lin, 2000, Schmidt, Machiels, Hermans, Tencate, Venekamp, & Boshuizen, 1996).

The lecture method of instruction is a passive way of teaching where the teacher is seen as the custodial of knowledge and the student is seen as a blank slate. In this method, only the teacher does the talking while the students are the passive listeners. This method is widely used in secondary schools in Nigeria because according to Ajaja (2009), it guarantees the teachers' completion of the course outline on time but on the other hand, encourages students to memorize content instead of digesting and assimilating them which leads to poor performance in Biology.

Apart from the teacher's method of instruction such as the conventional lecture method which has been reported as one of the major causes of poor performance in biology, over the years, sex has been identified as a predicting factor which affects students' achievement and retention. Sex in this study refers to the state of either being a male or a female. Okeke (2008) is of the opinion that males are usually bold, and tactful while females are gentle, fearful and submissive. Thus, for this reason, in school males are likely to take on more difficult subjects areas in science such as chemistry, physics and mathematics while females, on the other hand, may prefer biology and other subjects because they perceive them to be easier. The reports on gender as a predictive factor which influence students' achievement in various subject areas are varied. While some reports stated that gender has a significant influence on students' achievement and retention, others stated otherwise that there is no significant influence of sex on students' achievement and retention. Sex in this study is a moderator variable.

However, in this study, the researcher seeks to ascertain if the use of guided discovery and problem-solving instructional strategies could improve biology students' achievement and retention in biology with sex as a moderator variable. Against this background, the study was designed to determine the effects of guided discovery and problem-solving instructional strategies on the achievement and retention of Biology students in Delta Central Senatorial District.

2. Research Questions

The following research questions were used to guide the study.

1) Is there any effect of guided discovery on biology students' achievement?
2) Is there any effect of guided discovery on biology students' retention?
3) Is there any effect of problem-solving on biology students' achievement?
4) Is there any effect of problem-solving on biology students' retention?
5) Is there any difference in the mean achievement scores between male and female students taught biology using guided discovery and problem-solving methods?
6) Is there any difference in the mean retention scores between male and female students taught biology using guided discovery and problem-solving methods?

7) Is there any difference in the achievement scores of students taught biology using guided discovery, problem-solving and lecture methods?
8) Is there any difference in the retention scores of students taught biology with guided discovery, problem-solving and lecture methods?
9) Is there any interaction effect between teaching methods and sex on biology students' achievement?
10) Is there any interaction effect between teaching methods and sex on biology students' retention?

3. Hypotheses

The following hypotheses were tested at a 0.05 level of significance:

1) There is no significant effect of guided discovery on biology students' achievement.
2) There is no significant effect of guided discovery on biology students' retention.
3) There is no significant effect of problem-solving on biology students' achievement.
4) There is no significant effect on problem-solving on biology students' retention.
5) There is no significant difference in the mean achievement scores between male and female students taught biology using guided discovery and problem-solving methods.
6) There is no significant difference in the mean retention scores between male and female students taught biology using guided discovery and problem-solving methods.
7) There is no significant difference in the achievement scores of students taught biology using guided discovery, problem and lecture methods.
8) There is no significant difference in the mean retention scores of biology students taught with guided discovery, problem-solving and lecture methods.
9) There is no significant interaction effect between teaching methods and sex on biology students' achievement.
10) There is no significant interaction effect between teaching methods and sex on biology students' retention.

4. Methods

The design that was adopted for the study was the pre-test, post-test control group quasi-experimental design. In this study, students in the experimental group were exposed to treatment with the use of guided discovery and problem-solving instructional strategies in the course of learning the selected biology topics and there was no treatment administered to the control group. Thereafter, the mean achievement and retention scores of the students in both groups (experimental and control) were compared to determine the effects of guided discovery and problem-solving strategies on the achievement and

retention of biology students. The population for the study targeted all public senior secondary two (SS2) Biology students in Delta Central Senatorial District. There are 179 public secondary schools with a total population of 19,400 biology students. The SS2 students were used for the study because they had already been selected for a specific discipline and they were available to be used at the time of the study since they were not preparing for any external examination. The sample of the study consists of 238 SS2 Biology students from six mixed public senior secondary schools randomly selected from the schools in Delta Central Senatorial district of Delta State. The six mixed public secondary schools were selected using simple random sampling. Specifically, balloting with a replacement simple random sampling technique was used after eliminating all single-sexed schools so that every mixed school in the district will have an equal chance of being selected. The following criteria were used in the selection: trained, qualified and experienced Biology teachers, school must be mixed. Based on these criteria all the schools that lacked qualified Biology teachers and all single-sexed schools are eliminated from the study since sex is a moderator variable in this study.

The instrument that was used for data collection for the study was Biology Achievement Test (BAT) drawn from a six weeks lesson plan. The BAT covered the following topics: classification of plants (botanical, agricultural, and classification based on life cycle), digestive system (parts of the alimentary canal, modification and feeding mechanism). The BAT consists of 50 multiple choice test items constructed by the researcher and drawn from the 6 weeks instructional unit using a table of specifications. The face validity of Biology Achievement Test (BAT) was done by a panel of three experts made up of one science educator in Biology at Delta State University Abraka, one experienced Biology teacher drawn from Obiarukwu grammar school in Ukwani Local government area of Delta State and an expert in measurement and evaluation from Delta state University Abraka. The researcher gave copies of the initial draft of the BAT, six weeks of instructional units, research questions and hypotheses and the purpose of the study to the panel members to validate. The panel was requested to vet the items of the BAT for clarity of words, the plausibility of the distracters, appropriateness to the level of students and appropriateness of the six weeks of instructional units. They determined the face validity of the BAT instrument by examining critically the test items and relating them to the content of the 6 weeks of instructional units. Their corrections include: the expansion of the instructional units from 4 weeks to 6 weeks, instructional units for the guided discovery and problem group should include more students' activities, a column should be created for sex in the preliminary information on the BAT. Thereafter, their corrections /suggestions were effected in the instrument. The panel's approval of the test items as being able to measure what it intends to measure led to the use of the instrument for the study. The content validity of the instrument was done using a table of specifications which ensured that the questions covered all the contents in the six weeks instructional unit (lesson plan) in relation to the amount of time spent on each content.

The reliability of the BAT was established using the Kuder-Richardson 21 formula method. The researcher's choice of this approach is that it is most appropriate for establishing the reliability index of objective test items. The instruments were administered to 30 Obiarukwu Grammar School Biology students in Ukwani Local Government Area of Delta State who are outside the area of coverage for the study and the scores obtained were subjected to Kuder-Richardson 21 formula .On analysis of the test scores using Kuder-Richardson 21 formula, a reliability coefficient of 0.83 was obtained which met the standard specified by Johnson and Christensen (2000), Borich (2004) and Leedy & Ormord (2005) that any instrument with a reliability coefficient of 0.70 or higher is reliable. The data were analysed using paired sample t-test, independent sample t-test and ANCOVA at 0.05 level of significance.

5. Results

Question 1: Is there any effect of guided discovery on biology students' achievement?
Hypothesis 1: There is no significant effect of guided discovery on biology students' achievement.

Table 1: Paired Sample t-test Comparison on the Effect of Guided Discovery on Biology Students' Achievement

Group	N	Mean	SD	Df	t-cal	Sig. (2-tailed)	Decision
Pre-test	63	17.13	4.78	62	29.68	0.000	Ho is rejected
Post-test	63	40.92	5.70				

P<0.05

From Table 1 it is seen that the difference between the pre-test and post-test scores of the students is significantly different since the calculated sig. value of 0.000 is < 0.05. Therefore, Hypothesis 1 which states that there will be no effect of guided discovery on biology students' achievement is not accepted.

Question 2: Is there any effect of guided discovery on biology students' retention?
Hypothesis 2: There is no significant effect of guided discovery on biology students' retention.

Table 2: Paired sample t-test Comparison on the Effect of Guided Discovery on Biology Students' Retention

Group	N	Mean	SD	df	t-cal	Sig. (2-tailed)	Decision
Post-test	63	40.92	5.70	62	15.90	0.000	Ho is rejected
Follow-Up Test	63	36.33	5.42				

P>0.05

From Table 2 it is seen that the mean post-test score was 40.92, a standard deviation of 5.70 and follow-up retention score of 36.33 and a standard deviation of 5.42. Therefore,

Hypothesis 1 which states that there is no effect of guided discovery on biology students' retention is not accepted.

Question 3: Is there any effect of problem-solving on biology students' achievement?
Hypothesis 3: There is no significant effect of problem-solving on biology students' achievement.

Table 3: Paired sample t-test Comparison on the Effect of Problem-solving on Biology Students' Achievement

Group	N	Mean	SD	Df	t-cal	Sig. (2-tailed)	Decision
Pre-Test	91	16.73	6.21	90	29.62	0.000	Ho is rejected
Post-Test	91	40.78	4.73				

P<0.05

From Table 3 it is seen that the difference between the pre-test and post-test scores of the students is significantly different. Since the calculated sig. value of 0.000 is < 0.05, therefore Hypothesis 3 which states that there will be no effect of problem-solving on biology students' achievement is rejected.

Question 4: Is there any effect of problem-solving on biology students' retention?
Hypothesis 4: There is no significant effect of problem-solving on biology students' retention.

Table 4: Paired Sample t-test Comparison on the Effect of Problem-solving on Biology Students' Retention

Group	N	Mean	SD	Df	t-cal	Sig. (2-tailed)	Decision
Post-test	91	40.78	4.73	90	19.65	0.000	Ho is rejected
Follow Up Test	91	34.33	4.78				

P<0.05

From Table 4 it is seen that the mean post-test retention score of students is 40.78 while the follow-up score is 34.33. Therefore, Hypothesis 4 which states that there is no effect of problem-solving instructional strategy on biology students' retention is rejected.

Question 5: Is there any difference in the mean achievement score between male and female students taught biology using Guided Discovery and problem-solving methods?
Hypothesis 5: There is no significant difference in the mean achievement scores between male and female students taught biology using guided discovery and problem-solving methods.

Table 5: Independent Sample t-test Comparison of Post-test Mean Achievement Scores of Male and Female Students Taught Biology Using Guided discovery and problem-solving instructional strategies

Teaching Method	Sex	N		SD	Df	t-cal.	Sig. (2-tailed)	Decision
Guided Discovery	Male	26	38.73	6.89	61	2.47	0.018	Ho is rejected
	Female	37	42.46	4.13				
Problem-solving	Male	41	38.95	5.32	89	3.42	0.001	
	Female	50	42.28	3.60				

P>0.05

From Table 5 it is seen that male students had a mean achievement score of 38.73 with a standard deviation of 6.89 while female students had a mean score of 42.46 with a standard deviation of 4.13 for the guided discovery group. Male students had a mean achievement score of 38.95 with a standard deviation of 5.32 while female students had a mean score of 42.28 with a standard deviation of 3.60 for the problem-solving group. The difference between the post-test scores of the students in the two groups shows that there is a significant difference, therefore Hypothesis 5 is rejected.

Question 6: Is there any difference in the mean retention score between male and female students taught biology using guided discovery and problem-solving methods?
Hypothesis 6: There is no significant difference in the mean retention scores between male and female students taught biology using guided discovery and problem-solving methods.

Table 6: Independent Sample t-test Comparison on Mean Retention Scores between Male and Female Students Taught Biology Using Guided discovery and problem-solving instructional strategies

Teaching Method	Sex	N		SD	df	t-cal.	Sig. (2-tailed)	Decision
Guided Discovery	Male	26	34.35	6.32	61	2.55	0.013	Ho is rejected
	Female	37	37.73	4.23				
Problem-solving	Male	41	33.02	4.97	89	2.42	0.017	
	Female	50	35.40	4.38				

P>0.05

From Table 6, it is seen that the male students had a mean achievement score of 34.35 with a standard deviation of 6.32 while female students had a mean score of 37.73 with a standard deviation of 4.23 for the guided discovery group. Male students had a mean achievement score of 33.02 with a standard deviation of 4.97 while female students had a mean score of 35.40 with a standard deviation of 4.38 for the problem-solving group. The difference between follow-up scores of the students in the two groups is different in favour of guided discovery, Hypothesis 5 is rejected.

Question 7: Is there any difference in the achievement scores among students taught biology using guided discovery, problem-solving methods and lecture methods?

Hypothesis 7: There is no difference in the achievement scores among students taught biology using guided discovery, problem-solving methods and lecture methods.

Table 7: ANOVA Comparison on Achievement Scores of Students Taught Biology Using Guided Discovery, Problem-solving Methods and Lecture Method

	Sum of squares	Df	Mean square	F-ANOVA	Sig. (2-tailed)	Decision
Between group	9024.979	2	4512.489	160.138	.000	Ho is Rejected
Within group	6622.017	235	28.179			
Total	15646.996	237				

P<0.05

Table 7 shows that a significant difference was found between the groups taught with guided discovery, problem-solving and lecture methods. Therefore Hypothesis 7 was rejected. Thus, there is a significant difference in the mean achievement scores among students taught biology using guided discovery, problem-solving instructional strategies and lecture methods.

The direction of the difference among the three groups was established using Tukey's post-hoc test. The result shows that students in guided discovery performed better followed by those in problem-solving and then lecture method.

Question 8: Is there any difference in the retention scores among students taught biology using guided discovery, problem-solving methods and lecture methods?
Hypothesis 8: There is no difference in the retention scores among students taught biology using guided discovery, problem-solving methods and lecture methods.

Table 8: ANOVA Comparison on Retention Scores of Students Taught Biology Using Guided Discovery, Problem-solving Methods and Lecture Methods

Group	Sum of Squares	Df	Mean Square	F	Sig. (2-tailed)	Decision
Between group	9260.314	2	4630.157	188.066	.000	Ho is Rejected
Within group	5785.669	235	24.620			
Total	15045.983	237				

P<0.05

Table 8 shows that a significant difference was found between the groups taught with guided discovery, problem-solving and lecture methods. Therefore Hypothesis 8 was rejected. Thus, there is a significant difference in the mean retention scores among students taught biology using guided discovery, problem-solving instructional strategies and lecture methods. The direction of the difference among the three groups was established using Tukey's post-hoc test. The result shows that students in guided discovery retained better followed by those in problem-solving and then lecture method.

Question 9: Is there any interaction effect between teaching methods and sex on biology students' achievement

Hypothesis 9: There is no significant Interaction Effect between Teaching Methods and Sex on Biology Students' achievement

Table 9: ANCOVA Summary on Interaction of Teaching Methods and Sex on Biology Students' Achievement

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	9830.463[a]	6	1638.410	65.068	.000	.628
Intercept	27430.300	1	27430.300	1089.377	.000	.825
Pre-test	26.791	1	26.791	1.064	.303	.005
Teaching Method	8877.755	2	4438.877	176.287	.000	.604
Sex	778.675	1	778.675	30.925	.000	.118
Method* Sex	**3.067**	**2**	**1.534**	**.061**	**.941**	**.001**
Error	5816.533	231	25.180			
Total	329083.000	238				
Corrected Total	15646.996	237				

a. R Squared = .628 (Adjusted R Squared = .619)
b. Computed using alpha = .05

Table 9 shows that there was no significant interaction effect between teaching methods and sex as measured by students' mean achievement scores in biology. Therefore, the null hypothesis was not rejected. The result is further shown in Figure 1.

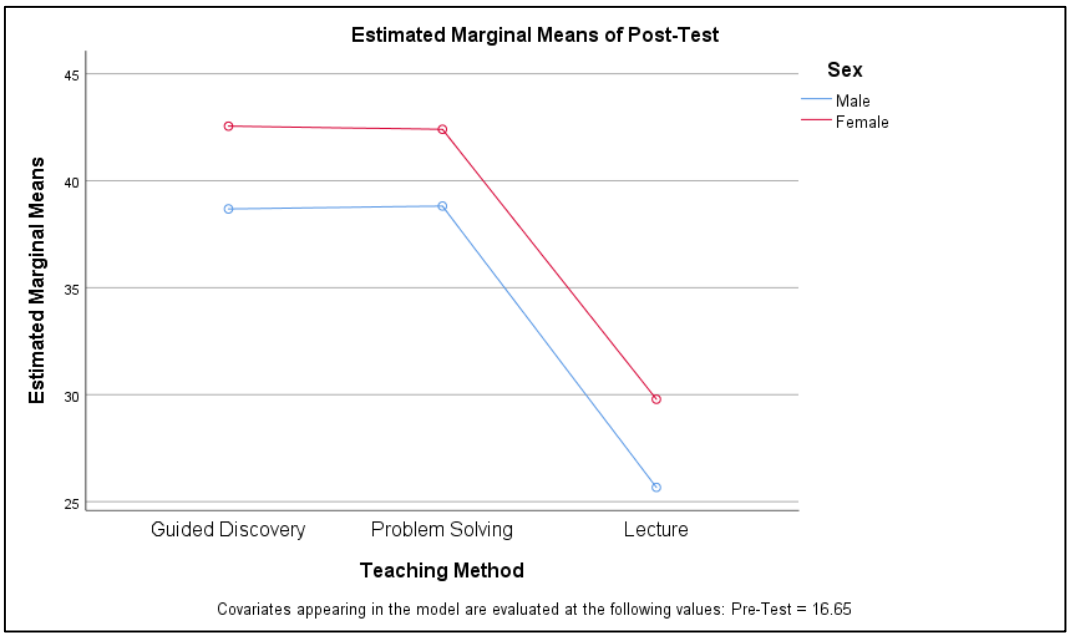

Figure 1: Plot of the Interaction of Teaching Methods and Sex on Biology Students' Achievement

Question 10: is there any interaction effect between teaching methods and sex on biology students' retention?

Hypothesis 10: there is no interaction effect between teaching method and sex on biology students' retention.

Table 10: ANCOVA Summary on Interaction of Teaching Methods and Sex on Biology Students' Retention

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	13727.404[a]	6	2287.901	400.814	.000	.912
Intercept	5.733	1	5.733	1.004	.317	.004
Pre-test	3882.507	1	3882.507	680.171	.000	.746
Teaching Method	252.661	2	126.330	22.132	.000	.161
Sex	1.466	1	1.466	.257	.613	.001
Method* Sex	**8.547**	**2**	**4.273**	**.749**	**.474**	**.006**
Error	1318.579	231	5.708			
Total	237606.000	238				
Corrected Total	15045.983	237				

a. R Squared = .628 (Adjusted R Squared = .619)
b. Computed using alpha = .05

Table 10 shows that there was no significant interaction effect between teaching methods and sex as measured by students' mean retention scores in biology. Therefore, the null hypothesis was not rejected. This result is further shown in Figure 2.

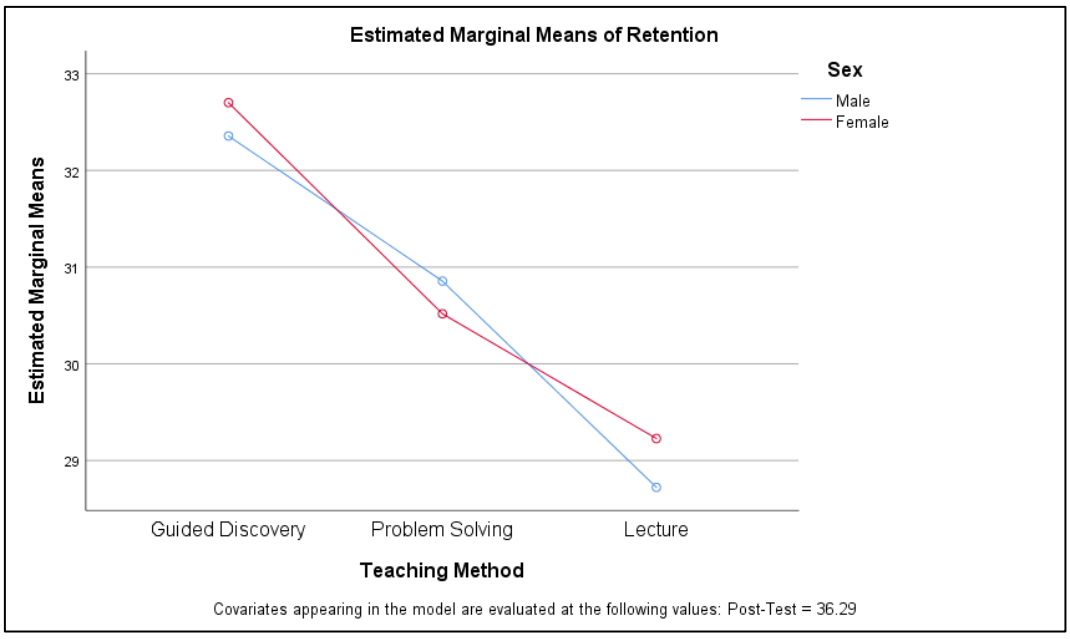

Figure 2: Plot of the Interaction of Teaching Methods and Sex on Biology Students' Retention

6. Discussion

The first finding of this study revealed that there is a significant difference in the mean achievement scores of students taught biology with guided discovery instructional strategy as seen in the pre-test and post-test scores. This difference can be attributed to the treatment given. This shows that guided discovery improves students' achievement. This result is consistent with that of Akanbi (2014), who investigated the impact of guided discovery and self-learning techniques on senior secondary school students' biology achievement and came to the conclusion that the intervention significantly improved the achievement scores of the students in biology. That is also consistent with Daja's (2015) investigation of the effects of guided discovery instruction on students' attitudes and biology achievement in senior secondary schools, which found that guided discovery improved students' performance.

The second finding of this study revealed that there is a significant difference in the mean retention scores of students taught biology with guided discovery instructional strategy as seen in the post-test and follow-up test scores. This difference can be attributed to the treatment given. This shows that guided discovery improves students' retention. This result is consistent with research by Fatokun and Eniaya (2014), who looked into the impact of guided discovery, concept mapping, and an integrated teaching strategy on student accomplishment and retention. The retention test's t-test analysis revealed that the experimental group's mean score was considerably higher than the control group. Also, the results are consistent with those of Ernest, Taiwo, and Adebayo's (2020) study on the use of guided discovery to enhance student retention, academic attitude, and achievement. They came to the conclusion that therapy increased student achievement and retention.

The third finding of this study revealed that there is a significant difference in the mean achievement scores of students taught biology with problem-solving instructional strategy as seen in the pre-test and post-test scores. This difference can be attributed to the treatment given. This shows that problem-solving improves students' achievement. This finding agrees with that of Ali, Hukamadad, Akhter and Khan (2010) who in their study examined the effect of using the problem-solving instructional method on the achievement of mathematics students. The analysis of their study revealed that problem-solving instructional method improved students' achievement.

The fourth finding of this study revealed that there is a significant difference in the mean retention scores of students taught biology with problem-solving instructional strategy as seen in the post-test and follow-up test scores. This difference can be attributed to the treatment given. This shows that guided discovery improves students' retention. This result is consistent with research by Jacobson and Obomanu (2011), who looked at how problem-solving teaching strategies affected student achievement and retention. After the data was reviewed, some retention and accomplishment

improvements were noted. This suggests that teaching techniques that encourage pupils to solve problems help them remember topics better.

The fifth finding of this study revealed that there was a significant difference in the mean achievement scores among students taught with guided discovery and problem-solving instructional strategies. The variations in the achievement scores among the groups may be due to the variation in the teaching strategies adopted in each of the groups and subject comprehension of the method of instruction. The analysis which indicated that all students taught with guided discovery and problem-solving strategies outscored those taught with the lecture method may suggest that the students in the experimental group may have been more active in the learning process than their counterparts in the lecture method group and thus has contributed to their higher achievement. This is hinged on the fact that one learns better by doing (Ajaja, 2013). The low achievement scores found among the students taught with the lecture method may be associated with the transmission approach involved, where the teacher passes over their knowledge to the students. Bennet (2003) noted that the transmission of view implies that students' role in the learning process is largely passive and that the students' mind is what is sometimes called 'tabula rasa'.

The significantly higher achievement of students taught with guided discovery and problem-solving instructional strategies over the lecture method of instruction as found in this study corresponds to the findings of earlier researchers on these methods. Studies by Anyafulude (2014), Ozioko (2015), Ozomadu (2016) established the relative efficacy of guided discovery and problem-solving instructional strategies in fostering students' achievement in biology relative to the lecture method.

This study also revealed that there was a significant difference in the mean retention scores among students taught with guided discovery and problem-solving. The difference in the retention scores among the groups may be due to the variation in the teaching strategies adopted in each of the groups and subject comprehension of the method of instruction. The analysis which indicated that all students taught with guided discovery and problem-solving strategies retained and outscored those taught with the lecture method may suggest that the students in the experimental group may have been more active in the learning process than those exposed to the lecture method group and thus has contributed to their higher retention. This is hinged on the fact that students learn and retain better by doing rather than mere observation. The low retention scores found among the students taught with the lecture method may be associated with the teaching approach involved, where the teacher passes over their knowledge to the students while the students are seen as a blank slate.

The significantly higher retention of students taught with guided discovery and problem-solving instructional strategies over the lecture method of instruction as found in this study corresponds to the findings of earlier researchers on these methods. Studies by Fatokun (2014), Ernest (2020), Jacobson (2011) established the relative effect of guided

discovery and problem-solving instructional strategies in fostering students' retention in biology relative to the lecture method.

The study also revealed that female students achieved higher than male students when exposed to treatment using guided discovery and problem-solving instructional strategies with a mean difference which was found to be insignificant. The reason for this observation may be a result of the fact that the females were more actively involved than their male counterparts. This is in line with the findings Ozioko (2015), Okoro (2011). They discovered in their study that there was no significant gender difference in the post-test achievement of the experimental group taught with expository and guided discovery methods in biology, notwithstanding the difference that existed in the pre-test result in favour of males. This indicated that with the use of any good teaching method such as guided discovery, male and female students will achieve equally (Ozioko, 2015).

The study also revealed that there is a significant difference between the mean achievement and retention scores of male and female students taught biology using guided discovery and problem-solving instructional strategies in favour of females. Female students retained higher than male students when exposed to treatment using guided discovery and problem-solving. The reason for this observation may be as a result of the fact that the females were more actively involved than their male counterparts. The female participated more in the teaching and learning process than the male. This finding however agrees with Adigun (2015).

The study also revealed that there was no significant interaction effect between teaching method and sex on students' achievement. This shows that guided discovery, problem-solving and lecture methods did not combine with sex to influence students' achievement towards biology. This finding does not agree with that of Danaia (2014) who observed a significant interaction effect of treatment and gender on students' academic achievement in social studies.

Lastly, the study further revealed no significant interaction effect between teaching method and sex on biology students' retention. This finding disagrees with that of Jacobson (2011), Abubaka and Danjuma (2012) who observed that there was an interaction effect between teaching method and sex on students' achievement and retention.

7. Conclusion and Recommendations

The study concluded that since there was a significant difference in the mean achievement and retention scores among students taught biology with guided discovery, problem-solving and lecture methods in favour of guided discovery and problem-solving, guided discovery and problem-solving instructional strategies enhance students' understanding, achievement and retention of biology concept more as compared to the lecture method. Also, since female students significantly out-performed their male counterparts when taught biology using guided discovery and problem-

solving instructional strategies, it is therefore concluded that guided discovery and problem-solving instructional strategies enhanced the mean achievement and retention score of female students more as compared to their male counterparts.

In light of the findings of the study, the following recommendations are made:

1) Biology teachers should adopt the use of guided discovery and problem-solving instructional strategies in the teaching of biology at the secondary school level. These instructional strategies will ensure students' active involvement, self-discovery of knowledge as well as interaction with the learning materials during the teaching–learning process.
2) Training on the effective implementation of guided discovery and problem-solving instructional strategies should always be organized for teachers and students by the government so as to help the teachers become competent in the use of these teaching strategies in the teaching and learning process.
3) Workshops and seminars should be organized for teachers and students to keep them abreast of other innovative active teaching strategies to enhance easy implementation in classroom teaching.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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References

Adigun, J., Irunokhai, E., Sada, Y., & Adesina, O. (2015). Effect of gender on students' academic performance in computer studies in secondary schools. *Journal of Education and Practice,* 6(33), 1.

Ajaja, O. P. (2009). Evaluation of science teaching in secondary schools in Delta state- 2 teaching of science. *International Journal of Science,* 1(2), 119-129.

Ajaja, O. P. (2013). Which strategy best suits biology teaching? Lecturing, concept mapping, cooperative learning of learning cycle? *Electronic Journal of Science Education,* 17(1), 1-36.

Akanbi, A. A., Kolawole, C. B. (2014). Effect of guided discovery and self-learning strategies on senior secondary school students' achievement in biology. *Journal of Education and Leadership Development,* 6(1), 19-42.

Ali, R., Hukamadad, Akhter, A., & Khan, A. (2010). Effect of using problem-solving method in teaching mathematics on the achievement of mathematics students. *Asian Social Science Journal,* 2(2), 118-128.

Anyafulude, J. (2014). Effect of problem-based learning strategy on students' achievement in senior secondary school chemistry in Enugu state. IOSR *Journal of Research and Method of Education (IOSR-JRME),* 4(3), 27-31.

Benneth, J. (2003). *Teaching and Learning Science.* London: Continuum.

Earnest, O. U., Taiwo, G. O. & Adedayo, I. O. (2020). Using guided discovery to improve students' retention and academic attitude to financial accounting concepts. *Educational Research International.*

Fatokun, K. V. F., & Eniayeju, P. A. (2014). The effect of concept mapping, guided discovery integrated teaching approach on chemistry students' achievement and retention. *Educational Research and Reviews,* 9(22), 1218-1223.

Fatokun, K. V. F., & Eniayeju, P. A. (2014). The effect of concept mapping, guided discovery integrated teaching approach on chemistry students' achievement and retention. *Educational Research and Reviews,* 9(22), 1218-1223.

Ganiyu, B., Adeboye, M. C. & Abimbola, I.O. (2007). Conceptions of the nature of Biology held by senior secondary school biology teachers in Ilorin, Kwara State, Nigeria. *Malaysian Online Journal of Education Sciences*, 5(3), 1-12.

Hmelo-Silver, C. E. (2004). Problem-based learning: what and how do students learn? *Educational Psychology Review,* 235-266.

Ifeobu, H. N. (2014). Evaluation of the implementation of national curriculum for secondary school biology in Anambra state. Unpublished PhD thesis, University of Nigeria, Nsukka.

Jacobson, B. N., & Obomanu, B. J. (2011). Assessment of the effect of problem-solving instructional strategies in students' achievements and retention in chemistry with respect to location in Rivers State. *World Journal of Education,* 1(2), 74-78.

Mayer, E. (2004). *The Autonomy of Biology*. Retrieved from https://www1.biologie.uni-hamburg.de/b-online/e01_2/autonomy.htm

Okeke, E. A. C. (2008). Clarification and analysis of gender concepts: Focus on research, reproductive health education and gender-sensitive classrooms. *Science Teachers Association of Nigeria-Gender and STM Education* 2, 5-8.

Okoro, A. U. (2011). Effects of interaction pattern on the achievement and interest in biology among secondary school students in Enugu State Nigeria (Unpublished M. ed Thesis). Department of Education, University of Nigeria, Nsukka

Ozioko, C. C. (2015). Effect of guided discovery method on academic achievement and interest of senior secondary school students in food and nutrition in Nsukka educational zone of Enugu state. Unpublished M.ED thesis submitted to the Faculty of Education, University of Nigeria, Nsukka.