

Effects Of Discovery Learning And Problem-Based Instructional Approaches On Secondary School Students' Achievement In Biology

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Abstract: *The study investigated the effect of discovery learning and problem-based instructional approaches on secondary school students' achievement in Biology. Three research questions guided the study and four hypotheses were tested at 0.05 level of significance. The quasi-experimental design with a 3x2 factorial background was adopted, for the study. The population of the study was 753 senior secondary school year two (SS2) biology students in Oshimmili North local government area of Delta state. A sample of 159 SS 2 biology students was involved in the study. The instrument for data collection were Biology Achievement Test (BAT) validated by one lecturers in the Department of Science Education, Nnamdi Azikiwe University, Awka and another in Delta State University, Abraka and one experienced secondary school biology teacher. The reliability of the BAT was established using Kuder Richardson formula 20 to be 0.85. Data collected by administering the instruments as pretest and posttest before and after treatment were analyzed using mean, standard deviation and analysis of covariance. The finding of the study revealed that there was significant difference in the mean achievement scores of the students taught using discovery learning, problem-based instruction and conventional method in favour of discovery learning followed by problem-based learning. The study recommended that orientation and seminars should be organized by school administrators for biology teachers to aid them in the mastery of discovery and problem-based learning and how to integrate them in the learning process of biology.*

Keywords: *Discovery, problem-based, learning, biology, achievement*

I. INTRODUCTION

Every sector of human development seeks to solve one problem or the other either by using skilled or unskilled labour. Thus, solving problems or proffering solutions to them should be the crux of any educational endeavour. However, in the field of education, a good number of educators appear to have ignored the need for learners to learn how to solve problems and instead they lay more emphasis on the acquisition of facts. This has resulted in lack of problem solving ability among students which is mostly expressed in their poor achievement in science subjects including biology.

The fields of Biology so listed clearly denote the importance of Biology both to human beings and the society as well as plants and other animals. Despite the importance of

Biology, students' achievement in Biology has not risen above average in most external examinations. Information from West African Examination Council (WACE)'s website relates students' weaknesses and strength in various subject areas. In Biology, the reports from 2010-2017 indicated that among other weaknesses, students' lacked the ability to interpret the questions, have shallow knowledge of the subject matter, and could not report experiments in sequential order; students lacked the ability to make proper observations and inference as candidates seemed to be writing based on theoretical knowledge.

The report stated that students manifested lack of understanding of the demands of the questions and showed weak performance in questions requiring detailed explanations and application of knowledge and that students' could not

draw images of objects according to specification/size and classify organisms. The report of the Chief Examiner was that students did not attempt compulsory questions, were making diagram of Nitrogen cycle instead of Carbon cycle and poorly attempted questions requiring detailed explanation. Students generally showed lack of knowledge of the important technical terms and had poor understanding of asexual reproduction among other weaknesses with similar observations were reported in 2016 and 2017 respectively.

The examination body having noted that the trend of poor achievement across the years in practical questions which present students with a problem to solve made some important recommendations. One of the important recommendations was made by WAEC during her 63rd meeting of the Nigerian Examinations Committee (NEC) held in 2017 at Conference center, Ogba, Lagos. The examination body recommended that teachers should engage students in practical classes not waiting till the instruction for practical's come out before exposing the students to the laboratories. This recommendation by NEC is owing to the fact that among the factors implicated for students' poor achievement in Biology, teachers' choice of teaching method holds common place. Biology teachers appear to hardly have recourse to laboratory approach to learning Biology which emphasizes discovery and problem solving which have the potentials to improve students' achievement.

Academic achievement is the outcome of education. It is the result of what an individual has learned from some educational experiences (Tucker, 2009). Academic achievement denotes how much students have learnt or mastered the concept taught. It could also be conceived as the students' numerical grade in a standard evaluation process such as examination. One major factor known to affect achievement is the teachers' choice of instruction. When innovative methods that involves the students actively in the process of learning such as problem-based instruction and discovery learning are used, there is likelihood that achievement may be improved. However, students are not presented with problems to solve (Anyafulude, 2014) neither are they challenged to discover important knowledge (Oziokor, 2015).

Discovery learning (DL) according to Mattingly, Lutkehaus, and Throop (2008) is a learning situation in which the principal content of what is to be learned is not given, but must be independently discovered by the learner, making the student an active participant in his learning. Discovery learning is a kind of learning that is based on the students finding things out by themselves, looking into problems, and asking questions. Discovery learning can be teacher guided or unguided discovery.

Guided-discovery is a teaching method, that enables learners create their own learning experience, with the guidance of their teacher. A guided-discovery method involves an unstructured exploration in some problem-based experiences in which students can draw general conclusions from data gathered through measuring, classifying, inferring, predicting, communicating, analyzing, clarifying, describing and formulating relevant questions (Moses, 2019). In unguided discovery, the teacher only provided the students with what is needed of them in terms of academic goals and

objectives. The students on their own acquire the needed experience without the guidance of the teachers. Guided discovery therefore, differs from unguided discovery only from the point of the assistance or guide provided by the teachers just as in problem-based learning.

On the other hand problem-based learning (PBL) approach is an active learning method based on the use of structured problems as a stimulus for learning (Barrows, 2010). In PBL students use the problem to direct themselves to research and learn the new knowledge needed. According to Mifflin (2004) the main characteristics of PBL is that :it is problem focused, such that learners begin learning by addressing simulations of an authentic, carefully structured problem; it is self-directed, such that students individually and collaboratively assume responsibility for generating learning issues and processes through self-assessment, peer assessment and access their own learning materials. In PBL, teachers are facilitators who support and model reasoning processes, facilitate group processes and interpersonal dynamics, and probe students' knowledge deeply. Since there are variety of problem based learning, this study will employ the approach to problem-based learning by Justine (2014). The problem based learning according to Justin consist of; creating a problem to solve, introducing problem-based techniques that might be applicable, allowing students to create their own paths to a solution, helping to develop collaborative working skills and identifying, confronting and discussing misconceptions.

Studies in discovery learning and problem-based instruction have shown that these instructional approaches bear the potentials for improving students' achievement and interest in various subject areas (Anyafulude, 2014; Jegede & Fatoke, 2014; Oziokor, 2015; Udo, 2010; Uside, Barchok & Abura, 2013). Discovery learning and Problem based learning are basic skills needed by today's learners. Guided by recent research in problem-based learning, change in professional standards, new workplace demands, and recent changes in learning theory, educators and trainers are revising the curricula. The essence is to include integrated learning environments which encourage learners to use higher order thinking skills, and in particular, discovery and problem solving skills. As education has come under criticism from many sectors, educators have looked for ways to reform teaching, learning, and the curriculum. Many have argued that the deviation from content during application has adversely affected Nigerian educational system (Nekang, 2013; Uside, Barchok & Abura, 2013). Learners often learn facts and rote procedures with few ties to the context and application of knowledge. Discovery learning and Problem-based instruction have become the means to rejoin content and application in a learning environment for basic skills as well as their application in various contexts (Jegede & Fatoke, 2014) unlike conventional teaching method.

Conventional teaching method entails the mix of methods employed by regular classroom teachers. Although conventional teaching method such as lecture method is good for teaching large number of students and covering large content areas, it has been criticized for making students' passive in the instructional process (Phillips, 2008). Despite the social constructivist's propositions and the unanimous

advocacy for students approaches to learning, a good number of teachers of Biology still use the conventional method of teaching (Oziokor, 2015). These teachers argue that student-centered methods especially discovery leaning and problem-based learning take time and may not fit into the time duration allotted for teaching and learning Biology in secondary schools. Discovering ideas and solving academic related problems require that students interact with one another, their teachers, learning content and learning materials in order to learn effectively. To ensure adequate interaction, students may be grouped. When they are grouped and presented with new objectives about what to discover and the problems to solve, the challenges of adopting these instructional methods may not only be solved, but students' achievement and interest may be improved irrespective of gender. However, there is no empirical evidence based on the researcher's knowledge as to how students' gender may influence their learning, achievement and interest when exposed to discovery and problem based instruction.

PURPOSE OF STUDY

The study focused on the effect of discovery learning and problem-based instructional approach on secondary school students' achievement in biology. Specifically, the study sought to:

- ✓ Compare the mean achievement scores of students in biology taught using discovery learning and problem-based learning method and those taught using conventional method.
- ✓ Find out whether the mean achievement scores of male and female students in biology taught using discovery learning would differ.
- ✓ Ascertain whether the mean achievement scores of male and female students in biology taught using problem based learning would differ.
- ✓ Find out the interaction effect of teaching methods and gender on achievement of students in Biology.

RESEARCH QUESTIONS

The following research questions guided the study.

- ✓ What are the mean achievement scores of students taught biology using discovery learning and problem-based learning and those taught using conventional method?
- ✓ What are the mean achievement scores of male and female students taught biology using discovery learning?
- ✓ What are the mean achievement scores of male and female students taught biology using problem based learning?

HYPOTHESES

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

- ✓ There is no significant difference in the mean achievement scores of students in biology taught using discovery learning and problem-based learning and those taught using conventional method?

- ✓ There is no significant difference in mean achievement scores of male and female students in biology taught using discovery learning?
- ✓ There is no significant difference in the mean achievement scores of male and female students in biology taught using problem based learning?
- ✓ There is no significant interaction effect of teaching methods and gender on achievement of students in biology.

II. METHOD

The design of this study is quasi-experimental. Specifically, the pre-test, posttest, non-equivalent control group design was used. The area of the study is Oshimili North Local Government Area of Delta State. The population of the study consists of all the 853 senior secondary school year two (SS2) students in the 10 public secondary schools in Oshimili North local government area of Delta state (Source: Ministry of Education, Akwuku-igbo, 2018). There are nine public co-educational and one single sex secondary schools in Oshimili North Local Government Area. The sample of the study is 159 (85 males, 74 females) SS2 Biology students. From the co-educational schools, purposive sampling was used to select three schools. The rationale for selecting the schools was because they are far apart and prevented class interaction which may lead to subject contamination. Simple random sampling was used to assign the school to experimental groups I and II and the control group. In each school selected, SS2 Biology students were used. In the school assigned as experimental group I, there were 22 males and 21 females. Experimental group II had 37 males and 24 females while the control group had 26 males and 29 females.

The instrument for data collection was Biology Achievement Test (BAT). BAT contained twenty-five objective test questions and was designed with two sections: A and B. Section A was designed to generate information on the biographic data of the students while section B contained objective test questions covering the content area taught in the study. The test questions were as adopted in past 2012-2018 question papers on Biology Senior Secondary School WAEC (SSWAEC) by Anyaele on the content areas covered. A Table of specification was used to ensure equivalent coverage of the major contents taught. BAT was validated by experts in the Department of Science Education, Nnamdi Azikiwe University Awka and another lecturer in the Delta State University, Abraka, and an experienced Biology teacher. The reliability of BAT was established using Kuder Richardson formula 20 (KR-20) to be 0.85.

The treatment was carried out in two phases: A and B. The first phase A consisted of briefing programme for the regular Biology teachers of the schools that were used in the experiment. The training lasted for one week in 3 contacts. Each contact lasted for 3 hours. The teaching of the students was preceded by a pretest using both the BAT and BIS. The activities that were carried out by the teachers of each instructional method are outlined as follows. Students were placed into groups of 4-6 students. In each group, a group leader was appointed who

coordinated the affairs of the group. Activities of the group were made known to the teacher through the group and during each lesson, students of the same group were made to arrange their seats in such a way that they can seat together and share ideas. No student was allowed to select his or her own group members.

In the experimental classrooms where discovery learning and problem-based instructional strategies was applied, the following steps as recommended by Justin (2014) and Wood (1975) respectively was followed.

DISCOVERY LEARNING CLASSROOM: The teacher in the discovery learning class incorporated the following basic processes of discovery learning into the group's experience: a) observing, b) classifying, c) measuring, d) predicting, e) describing and f) inferring as recommended by wood (1975). The basic steps that was adopted by teachers in the discovery-learning group as recommended by Justin and Wood are as follows:

- ✓ Defining the Problem: Teacher helped students define the problem by asking thought provoking questions. This enhanced students' in-depth understanding of the problem and also enable them state feasible hypothesis that guided their discovery of the solution to the problem.
- ✓ Guiding students plan where and how to gather data and information: Teacher gave students directives on where to get information, ensure the availability of necessary materials that can enable the students to gather and interpret data in the quest of solving the problem.
- ✓ Students' presenting of findings through graphs, charts, models, and writing. Teacher evaluated students' discoveries to ensure that they are in accordance with scientific ideas. The teacher pointed out misconceptions and wrong ideas while communicating to the students the right information which they could not discover.

PROBLEM SOLVING CLASSROOM: In the problem-based classroom, the teacher who taught there performed the following activities by applying the approaches recommended by Justin (2014) and Wood (1975). The approaches consist in:

- ✓ Beginning with a task embedded in a familiar setting
- ✓ Introducing problem-based techniques that might be applicable
- ✓ Allowing students to create their own paths to a solution
- ✓ Emphasizing collaborative learning and problem solving
- ✓ Helping to develop collaborative working skills
- ✓ Providing different roles for individuals in a group setting
- ✓ Identifying, confronting and discussing misconceptions.

In both of these methods, problems and discoveries were done in groups. The activities were carried out in groups but the assessments and evaluations were done on individual basis to ensure active participation of each member of any group. In the control group, the students were taught the same content by the classroom teacher who did not use discovery learning or problem-based approach but conventional method. All three groups were administered with a posttest after the four weeks of teaching.

BAT was administered to the students as pretest in the first week before the commencement of the treatment. The students were also given the same instrument reshuffled and printed on a coloured paper as posttest after the treatment. Their scores were collated and organized for analysis. Data

relating to the research questions were analyzed using mean and standard deviations. The hypotheses were tested using analysis of covariance (ANCOVA). The decision rule was that when the probability value (P-value) is less than 0.05, the null hypothesis was rejected, otherwise, the null hypothesis was not rejected.

III. RESULTS

RESEARCH QUESTION 1: What are the mean achievement scores of students taught biology using discovery learning and problem-based learning and those taught using conventional method?

Source of Variation	N	Pretest Mean	Posttest Mean	Gain in Mean	Pretest SD	Posttest SD
DL	43	23.72	79.95	56.23	10.92	4.67
PBL	61	18.69	70.57	51.88	9.57	8.67
CM	55	19.09	49.55	30.46	9.38	4.64

Table 1: Pretest and Posttest Mean Achievement Scores of Students taught Biology using Discovery Learning (DL), Problem-based Learning (PBL) and Conventional Method (CM)

Table 1 reveals that the students taught biology using discovery learning has gain in mean achievement score of 56.23 while those taught using problem-based learning has gain in mean achievement score of 51.88 where those taught using conventional method has gain in mean achievement score of 30.46. In the pretest, students taught using discovery learning had the highest spread of score (10.92). In the posttest, the spread of scores was highest among the students taught using problem-based learning (8.67).

RESEARCH QUESTION 2: What are the mean achievement scores of male and female students taught biology using discovery learning?

Gender	N	Pretest Mean	Posttest Mean	Gain in Mean	Pretest SD	Posttest SD
Male	22	22.50	81.05	58.55	10.63	4.71
Female	21	25.00	78.81	53.81	11.29	4.45

Table 2: Pretest and Posttest Mean Achievement Scores of Male and Female Students taught Biology using Discovery Learning

Table 2 shows that male students taught using discovery learning has gain in mean achievement score of 58.55 while the females have gain in mean achievement score of 53.81. There was higher spread of scores in the posttest among the males (4.71) than among the females (4.45).

RESEARCH QUESTION 3: What are the mean achievement scores of male and female students taught Biology using problem based learning?

Gender	N	Pretest Mean	Posttest Mean	Gain in Mean	Pretest SD	Posttest SD
Male	37	19.32	70.95	51.64	10.15	8.65
Female	24	17.83	70.65	52.82	8.90	8.44

Table 3: Pretest and Posttest Mean Achievement Scores of Male and Female Students taught Biology using Problem-based Learning

Table 3 shows that male students taught using problem-based learning has gain in mean achievement score of 51.64

while the females have gain in mean achievement score of 52.82. There was higher spread of scores in the posttest among the males (8.65) than among the females (8.44).

HYPOTHESIS 1: There is no significant difference in the mean achievement scores of students in biology taught using discovery learning and problem-based learning and those taught using conventional method.

Source of variation	SS	Df	MS	F	P-value	Decision
Corrected Model	24555.890 ^a	3	8185.297	193.348	.000	
Intercept	127966.752	1	127966.752	3022.749	.000	
Pretest	20.603	1	20.603	.487	.486	
Method	23893.505	2	11946.753	282.199	.000	S
Error	6561.858	155	42.335			
Total	720294.000	159				
Corrected Total	31117.748	158				

Table 4: ANCOVA on test of Significant Difference in the Mean Achievement Score of Students taught Biology using Discovery Learning, Problem-based Learning and those taught using Conventional Method

Table 4 shows that at 0.05 level of significance, 1df numerator and 158df denominator, the calculated F is 282.199 with Pvalue of 0.000 which is less than 0.05. Therefore, the null hypothesis was rejected. Thus, there is significant difference in the mean achievement scores of students in biology taught using discovery learning and problem-based learning and those taught using conventional method. The order of significance is shown in Table 5.

(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	Sig. ^b
DL	PBL	9.195*	1.322	.000
	CM	30.238*	1.347	.000
PBL	DL	-9.195*	1.322	.000
	CM	21.043*	1.210	.000
CM	DL	-30.238*	1.347	.000
	PBL	-21.043*	1.210	.000

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

Table 5: Scheffe PostHoc on Differences in the Mean Achievement Scores of Students taught using DL, PBL and those taught CM

Table 5 reveals that significant difference exists between the mean achievement scores of students taught using DL and those taught using PBL in favour of those with DL. Table 8 also reveals that a significant difference exists between the mean achievement scores of students taught with DL and those taught using CM in favour of DL. Table 8 further shows that significant difference exists between the mean achievement scores of those taught with PBL and those taught using CM in favour of PBL.

HYPOTHESIS 2: There is no significant difference in mean achievement scores of male and female students in Biology taught using discovery learning.

Source of variation	SS	Df	MS	F	P-value	Decision
Corrected Model	82.576 ^a	2	41.288	1.987	.150	
Intercept	48592.992	1	48592.992	2338.083	.000	
Pretest	28.862	1	28.862	1.389	.246	

Gender	44.321	1	44.321	2.133	.152	NS
Error	831.331	40	20.783			
Total	275794.000	43				
Corrected Total	913.907	42				

Table 6: ANCOVA on test of Significant Difference in the Mean Achievement Score of Male and Female Students taught Biology using Discovery Learning

Table 6 shows that at 0.05 level of significance, 1df numerator and 42df denominator, the calculated F is 2.133 with Pvalue of 0.152 which is greater than 0.05. Therefore, the null hypothesis was not rejected. Thus, there is no significant difference in mean achievement scores of male and female students in Biology taught using discovery learning.

HYPOTHESIS 3: There is no significant difference in the mean achievement scores of male and female students in Biology taught using problem based learning.

Source of variation	SS	Df	MS	F	P-value	Decision
Corrected Model	73.328 ^a	2	36.664	.480	.621	
Intercept	58697.810	1	58697.810	768.228	.000	
Pretest	60.302	1	60.302	.789	.378	
Gender	8.707	1	8.707	.114	.737	NS
Error	4431.590	58	76.407			
Total	308325.000	61				
Corrected Total	4504.918	60				

Table 7: ANCOVA on test of Significant Difference in the Mean Achievement Score of Male and Female Students taught Biology using Discovery Learning

Table 7 shows that at 0.05 level of significance, 1df numerator and 60df denominator, the calculated F is .114 with Pvalue of 0.737 which is greater than 0.05. Therefore, the null hypothesis was not rejected. Thus, there is no significant difference in mean achievement scores of male and female students in Biology taught using problem-based learning.

HYPOTHESIS 7: There is no significant interaction effect of teaching methods and gender on achievement of students in Biology.

Source of variation	SS	Df	MS	F	P-value	Decision
Corrected Model	24633.198 ^a	6	4105.533	96.235	.000	
Intercept	125300.461	1	125300.461	2937.084	.000	
Pretest	26.287	1	26.287	.616	.434	
Method	23729.687	2	11864.844	278.116	.000	
Gender	26.014	1	26.014	.610	.436	
Method *	57.217	2	28.608	.671	.513	NS
Error	6484.551	152	42.662			
Total	720294.000	159				
Corrected Total	31117.748	158				

Table 8: ANCOVA on Interaction Effect of Teaching Methods and Gender on Student' Achievement in Biology

Table 8 shows that at 0.05 level of significance, 1df numerator and 158df denominator, the calculated F is .671 with Pvalue of 0.513 which is greater than 0.05. Therefore, the null hypothesis was not rejected. Thus, there is no significant interaction effect of teaching methods and gender on achievement of students in Biology.

IV. DISCUSSION

The revealed that significant differences existed between the mean achievement scores of students taught using discovery learning, problem-based learning and conventional method in favour of discovery learning, followed by problem-based learning. The observed difference in favour of discovery learning could be attributed to the fact discovery learning focused on hands-on learning opportunities for students. It enabled students to discover new knowledge guided by the teacher. The discovery of new knowledge by students increased their motivation owing to the fact that since they were able to discover knowledge, they could do so in other related issues. Such motivation also drives the interest to learn and results in academic resilience.

Another plausible explanation for the observation is that discovery learning engaged many senses of the learner. Through learning by discovery, all six domains of cognition were called to play. The basic as well as the integrated science process skills and all previous knowledge possessed by learners are actively engaged. When such level of learning experiences are involved, students learn meaningfully and may retain learning for a fairly long period of time. The meaningful learning and interaction with learning materials results in improved academic achievement.

The findings of the study is in line with the findings of Oziokor (2015) that students taught using guided discovery method achieved significantly better than those taught using lecture method. The finding of the study also support that of Uside, Barchok & Abura (2013) that discovery learning has significant effect on the achievement of students by enhancing knowledge retention and instilling confidence. The findings by Udo (2010) supports the findings of the study when it reported that guided discovery was the most effective followed by student-centered demonstration.

It was found also that problem-based learning was significantly better than conventional teaching method. The observed significant difference in achievement could be as a result of the learning engagement resident in problem-based learning. In problem-based learning, students apply the skills of using previous subject knowledge and general analysis/synthesis skills. Students focused on the problem while relating it to other knowledge to be able to find solutions to the problem thereby making them actively engaged in the learning process.

The students in the problem-based learning group also through such learning approach developed such skills as is required for solving other related problem which mainly higher-order thinking skills. Consequently, they were able to process learning materials and information more meaningfully than those taught using conventional method. Ability to solve a problem gave the students confidence to tackle other academic tasks. When they tackled other similar tasks successfully, their confidence grew higher. With such high confidence students could solve related problems and improve their academic achievement.

The finding of the study is in line with that of Jegede and Fatoke (2014) students taught using problem-based learning had the greatest performance in chemistry. Nekang (2013) finding that students exposed to Rusbult's Problem Solving

Strategy (RUPSS) achieved higher than those exposed to conventional teaching method, supports the findings of the study.

The finding of the study showed that there was no significant difference between the mean achievement scores of male and female students taught using discovery learning. No significant difference was also found between the mean achievement scores of male and female students taught using problem-based learning. The observed results were because the methods were as much engaging for male students as it was for female students.

The findings of the study is line with that of Udo (2010) that gender had no significant effect on students' achievement in chemistry when taught using guided discovery. The finding of the study supports that of Jegede and Fatoke (2014) that gender had no significant influence on students' achievement in chemistry when problem solving strategy was used. The findings of the study also support the findings of Nekang (2013) that there is no statistically significant interaction effect between gender and strategy as measured by the mean achievement scores.

V. CONCLUSION

It can be concluded based on the findings of the study that discovery learning significantly improves students' achievement in biology. Another effective method for teaching biology after discovery learning is problem-based learning.

VI. RECOMMENDATIONS

In line with the findings of the study, it was recommended that:

- ✓ Orientation and seminars should be organized by school administrators for biology teachers to aid them in the mastery of discovery and problem-based learning and how to integrate them in the learning process of biology.
- ✓ Students of biology should be given thought-provoking questions that could serve as a guide in discovery new knowledge and to acquire the skills in solving other similar problems, when they succeed at solving the given problems.

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