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Effectiveness of Guided and Open Inquiry Instructional Strategies on Science Process Skills and Self-Efficacy of Biology Students in Osun State, Nigeria

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Abstract

The study determined the effectiveness of guided and open inquiry instructional strategies on the science process skills of students taught Biology in senior secondary schools in Osun State, Nigeria. It also compared the self-efficacy of students taught Biology using guided inquiry with those taught Biology using open inquiry instructional strategies in senior secondary school in Osun State. The goal was to provide empirical information on the effectiveness of guided and open inquiry strategies on students' learning outcome in Biology. The study adopted the non-equivalent pretest posttest quasi-experimental research design. Two research instruments were used to collect data for the study namely, (i) Biology Process Skills Observation checklist (BPSOC) and (ii) Self-efficacy Rating Scale (SeRS). Data collected were analyzed using appropriate inferential statistics of analysis of Covariance. The results showed that there was no significant difference in the science process skills of Biology students exposed to Open Inquiry and those exposed to guided inquiry strategy ($F= 0.785$, $p>0.05$). The results also showed that a significant difference existed in the self-efficacy of students taught using Guided Inquiry and Open Inquiry strategies ($F = 11.64$, $p < 0.05$) as those exposed to Open Inquiry had the better self-efficacy score than the other groups as shown in the mean difference between open and guided inquiry strategies. The study concluded that Open inquiry strategy

was more effective in improving the self-efficacy of the respondents but was not effective in improving the science process skills of respondents in the study area.

Keywords: Science Education, Biology, Science process skills, Self-efficacy, Inquiry instructional strategies.

1. INTRODUCTION

Science education is believed to help train students to think like scientists, and this will demand creative thinking, guided by the spirit of inquiry. Maranan, (2017) believed that the development of science process skills can help to develop academic performance of students in Biology and science subjects alike. The development of concepts, theories and laws is premised on curiosity which could also be said to be based on the spirit of inquiry in science students. Science process skills are the foundations upon which appropriate science activities are built, and they must be taken into account in the new national science curricula and textbooks. Students should be exposed to more activity-based settings and environments in order to acquire science process skills. As a result, we may argue that science process skills are at the heart of inquiry-based learning. Mastering science process skill and scientific investigation, as well as its application is the core of science, and this is developed through inquiry teaching and learning (Ngoh, 2009).

Omorogbe and Ewansiha (2013) explained that over the last two decades, there have been repeated calls for innovation and reformative processes towards development of Science Education in Nigeria. This is attributed to various challenges with the teaching and learning of science in Nigeria. This challenge necessitates investigation into the teaching and learning procedures adopted for science in various educational institutions. Science is an organized body of knowledge in form of concepts, laws, theories and generalizations. This body of knowledge is generated through questions, inquires and curiosity in students across various levels of education. These levels of curiosity are supposed to generate various ideas that will be beneficial for societal development. This shows that science is an important component that would catalyze the development of any society.

According to Urevbu (2001), science is the study of nature and natural events with the goal of discovering its principles and laws. Content, process, and attitude are all intertwined in science. Physical, life, and earth sciences content can be separated. The physical aspect at secondary school level is observed in teaching subject of Physics and Chemistry. The life and earth science is observed in Biology. The teaching and learning of each of these aspects are

important so that students that learn concepts in these fields can contribute positively in the society. Biology is important in intimating students about their health, environment and other factors relating to their living. Biology which is generally defined as the study of life is expected to help students to live healthy, provide information relating to healthy living through concepts learnt about their body system, and their environment as well as those organisms living in such environments. The teaching and learning of Biology at all levels is expected to promote knowledge and understanding of this concept hence having tremendous influence on health and environmental sector of the Nigerian society.

However, inadequate teaching methodology has been one of the key challenges facing science education in Nigerian secondary schools, and other levels of education (Omoifo, 2012). A common ground of agreement among researchers is that quality and adequate understanding of teaching methodology will lead to effectiveness in the teaching and learning of scientific concepts. Teaching can be said to be effective when the aims, goals and objectives of education has been achieved and this is usually measured through various learning outcomes. It goes beyond repetition of scientific knowledge but an entrainment of aims, goals, objectives and attitude of the students in science (Omoifo, 2012*).* The quality of teaching and learning will be important in improving understanding of basic concepts. Quality teaching, according to Okafor (2007), is defined by the teacher's ability to translate written knowledge into pedagogically powerful forms that are adaptable to the students' skills and backgrounds. This quality is measured through learning outcomes. Such learning outcomes include academic performance, process skills, retention, self-efficacy as well as attitudes.

Another component of science learning outcome which is important is the development of science process skills. This is important in the building of the contents of science as the application and acquisition of process skills are important in achieving this. It is believed that the acquisition of the process skills will help to develop the acquisition of scientific knowledge and also help to improve the mastering of the skills. Science process skills is believed to develop an environment that encourages thinking and finding out new things hence, emphasizing the importance of scientific inquiry in development of process skills (Salami, 2012; Kareem, 2019). A science process skill (SPS) is a set of mental and physical talents that children require in order to understand science and technology, and to address personal and social problems (Akinbobola & Afolabi, 2010). These skills are used for improving ones skill, training students while studying and applying the skills to solving everyday challenges (Ozturk, Tezel, & Acat, 2010). Science Process Skill is a key in developing science literacy for tackling

complex science and technology problems in the 21st century (Rahayu, 2016). Unfortunately, research has revealed that many teachers struggle with the science process (Kurniawan & Fadloli, 2016). This is due to lack of planning and implementation skills when conducting experiments (Sukarno, Permanasari, Hamidah, & Widodo, 2013).

Furthermore, it is expected that students' science skill can lead to improvement in their learning outcomes and develop positive perspective and attitude in science. This will help to build student's self-efficacy which is another component of students learning outcomes. Self-efficacy is the conviction that one can effectively carry out the actions required to achieve a desired result, and it is a key factor in determining whether or not a person engages in a particular behaviour.

In this case, self-efficacy can be defined as student's belief that they will perform well in Biology. Students who have good academic performance and have mastered skills in Biology will be confident of their outputs in the subject. Learners are thought to avoid behaviours that are beyond their capacities and instead conduct acts that they believe are within their capabilities" (Cecil & Pinkerton, 2000). As a result, self-efficacy levels can be utilized as a gauge of a person's confidence in his or her ability to engage in biological activities. It has also been described as person's conviction/belief that he/she can successfully achieve/attain the desired levels, goals and stages in matters pertaining to life in general (Feltz, Short & Singleton, 2008).

Warner and Myers (2014) wrote that while completing inquiry-based lessons, students develop important skills that will help them become successful, lifelong learners. This statement is in agreement with the views of Hughes (2014) and Franklin (2015). The inquiry-based learning depends on four essential elements which are un-deceptive patterns and meanings of concepts to the beginners, structured useful knowledge, applying the structured knowledge, transferring and accessible in situations and lastly, the structured knowledge should be made available for new information in that field to strive (Teach-nology.com, 2017).

Problem solving, critical thinking, reflective inquiry, and deductive thinking are all examples of inquiry teaching methods. It is a teaching style that entails probing, discovering, analysing, synthesising, discovering, assessing, questioning, and thinking (Muhammad, 2011). In a related development, the inquiry method is characterized as a teaching approach that significantly relies on the learner's participation in the learning activity. The strategy is founded on the notion that the subject will actively learn by completely engaging in the learning task. It

is an approach that leads to successful learning results that are relevant to the learner (Muhammad in Muhammad, 2011).

According to Muhammad (2011), Kyle and Gadsden (1996) defined inquiry teaching as a mode of instruction in which students study concepts, existing issues, probe and question them freely, and practice on their own or with little teacher assistance. Students seek information to answer or solve their difficulties, according to the author. As a result, inquiry teaching is both educational and exploratory, as well as a lot of fun and delight for students who learn via completing tasks. The inquiry process places a premium on the student's ability to think like a scientist.

The most difficult aspect of inquiry-based learning is open inquiry, which allows students to choose from a variety of inquiry topics and methods to the study once the teacher describes the phases in which the knowledge will be imparted. As a result, the open inquiry approach allows students to make judgments at each stage of the study, beginning with determining the most fascinating topic to investigate. Questioning, building an experimental array, critical and logical thinking, and reflection are all examples of open inquiry that assist students reflect on the type of research and experimental work that should be done. Students who participated in such a process demonstrated ownership and took responsibility for deciding the objective of the inquiry and proposed concerns to be investigated like a scientist would, according to Reid and Yang (2002). The teacher's efforts to promote the student's scientific literacy, initiative, responsibility, and motivation are intimately related to the student's functioning. Open inquiry fosters a learning atmosphere for teachers and students, which helps the inquiry process succeed (Zion & Slezak, 2005).

Irinoye, Bamidele, Adetunji and Awodele, (2015) stressed the importance of guided inquiry by explaining how it aids students' academic performance in science. Guided enquiry helps students to discover different abilities on their own and helps to promote understanding and individual learning. Uzezi and Zainab (2017) also believed that guided inquiry encourages students to engage in scientific researches and also pick up a career that would involve hands on activities. It is important to teach science using guided discovery method as it promotes and encourages investigation as rightly stated by Adetunji (2007) that investigation is an important component in teaching so that students can learn to discover themselves. It is assumed that guided inquiry strategy will assist learners to form their own concepts and consequently enhance performance, skills and self-efficacy in Biology. In Guided inquiry, students investigate questions and procedures presented by the teachers while the students work together

to decide the processes and the expected solution to be derived although the results of the study are not known to the teachers and the pupils at this stage. Unlike the open inquiry where the students decide the inquiry questions, in this guided inquiry, the teacher helps to reduce the degree of uncertainty by providing the student with inquiry questions and procedures. Zion and Mendelovici (2015) said that students make decisions from the data collection stage which might lead the students to formulate a preplanned result or conclusion. In this strategy, the teachers rendered to some assistance and guidance to the students to help them investigate into a problem and construction of knowledge.

Open inquiry strategy will demand that students become more involved in gaining scientific knowledge. It is also believed that when students learn effectively through appropriate use of methods and strategies, they would have better learning outcomes which has been a source of concern for Science (Biology) students. It is also believed that effective teaching could amidst students engage in adequate teaching and learning which could improve their process skills and self-efficacy in Biology.

Strategy like inquiry (open and guided) strategies have been found to improve learning outcomes and it has been encouraged to be used to promote thinking in the 21st century. More so, as the National Policy of Education has one of its cardinal points in improving scientific understanding and development of the spirit of inquiry in students. This spirit of inquiry can be developed through inquiry-based teaching.

Research has proven the importance of the inquiry strategies but not much attention has been paid to how the inquiry can be used. The variant of the inquiry strategy include the open and guided inquiry strategy. It is important to explore which of these types of inquiry strategies will better promote science process skills and self-efficacy in Biology; hence, this study.

OBJECTIVE OF THE STUDY

The specific objectives of the study are to:

- examine the science process skills of students taught Biology using guided inquiry and open inquiry instructional strategies in senior secondary schools in Osun State; and
- assess the self-efficacy of students when taught Biology using guided inquiry and open inquiry instructional strategies in senior secondary school in Osun State.

RESEARCH HYPOTHESES

Based on the objectives of this study, the following research hypotheses were raised:

- There is no significant difference in the science process skills of students taught Biology using guided and open inquiry instructional strategies in senior secondary schools in Osun State; and
- There is no significant difference in the self-efficacy of students taught Biology using guided and open inquiry instructional strategies in senior secondary school in Osun State.

2. METHODOLOGY

The study adopted non-equivalent pre-test, post-test quasi-experimental-design. Three groups were created for the study. The First group (Experimental Group-I))was treated with Guided Inquiry, the second group (Experimental Group-II))was treated with Open Inquiry strategy while third-group which served as the control group was treated using the conventional teaching strategy. The pre-tests for performance, process skills and self-efficacy were administered before treatment. Also, the post-tests for performance, self-efficacy and process skills were administered after the treatment. The design for the study is presented schematically below:

Experimental Group I	O_1 X_1 O_4
Experimental Group II.	O_2 X_2 O_5
Control Group	O_3 O_6

Where

O_1 O_2 O_3 == Pre-test for Exp. Group I, Exp. Group II & Control Group respectively

O_4 O_5 O_6 == Post-test for Exp. Group I, Exp. Group II & Control Group respectively

X_1 == Treatment using guided inquiry strategy

X_2 == Treatment using open inquiry strategy

Independent variables include treatments used for the study which are Guided and Open Inquiry strategies. The dependent variables are students' performance, process skills and self-efficacy. The research design used validated the effectiveness of the variables and helped in the evaluation of independent variables' effectiveness on academic performance, process skills and self-efficacy in studying Biology.

Target study population comprised Senior Secondary School Biology students in Osun State, while accessible population comprised Senior Secondary School One (SSS I) Biology students in Ile-Ife.

Multistage Sampling Procedure was used to select the sample for the study. From the three senatorial district of Osun state, Ones senatorial district was selected using simple random sampling technique. One-Local Government Area (LGA) was then sampled from the selected senatorial district using simple random sampling technique. Furthermore, three schools were selected using simple random sampling technique from the selected Local Government Area. One intact SS1 science class which was the science arm of the class was purposively selected in each of the schools. The purpose is because only Science classes are compelled to take Biology in secondary schools in Nigeria. The three intact classes were assigned to three groups using simple random sampling technique. Students in experimental group A were-exposed to guided inquiry while those in experimental group B were-exposed to open inquiry instructional strategy and those in experimental group C were taught-using conventional method. The topic taught was basic ecological concepts. The subtopics under this topic include environment, biosphere, lithosphere, atmosphere, habitat, population, and components of an ecosystem.

Table 1: Schools Selected and their Assignment to Treatment

Group	Name of school	Treatment type	No of students
A	Oduduwa College, Ile-Ife	Guided Inquiry	39
B	St. David Grammar School, Ile-Ife	Open Inquiry	44
C	Seventh Day Grammar School, Ile-Ife	Expository (Control group)	35
		Total	118

Biology Process Skills Observation Checklist (BPSOC) and Biology Self-efficacy Rating Scale (BSeRS) were used to collect data for the study. Biology Process Skills Observation Checklist (BPSOC), developed by Njoku (2002), provided information on students' process skills in Biology; and Biology Self-efficacy Rating Scale (BSeRS) was used to examine the student's efficacy skills in Biology. This was developed by Gaumer Erickson and Noonan (2018) and Schwarzer and Jerusalem (1995).

Copies of the instruments were administered on SS1-students of Atakumosa Grammar School, Osu who were not part of the study, to validate the research instruments. Responses

from the administered BPSOC and BSeRS were subjected to factorial analysis for the construct validity of the instrument to be verified before reliability test was carried out for each of the sections of the instrument. The results for each of the section were presented as follows.

Validation of BSeRS

This Section contained 20 items on students' self-efficacy in Biology. The responses were scored Strongly Agree, Agree, Disagree-and-Strongly Disagree. The KMO value revealed a value of 0.550 which was closer to 1 with p = 0.000 which is appropriate according to Kaiser (1974) and this shows the questions in the listed sections were adequate. This agrees with the minimum standard which should be passed. According to Kaiser (1974) values within 0.6 to 0.8 are adequate enough and could be used to measure was it was purported to measure. Also revealing a four component rotated matrix, the items could be judged adequate. Seven (7) poorly performing items (Items B2, B5, B11, B16, B17, B18 and B20) deleted from the original scale, resulting in the proposed 13 items measure.

To ascertain the reliability of the instrument, Cronbach Alpha Reliability, Test-re-test method and Spearman-Brown Coefficient were carried out on the remaining 13 items.

Reliability of BSeRS

The reliability of the-instruments in this section using Cronbach alpha coefficient revealed a factor of 0.758 which is very acceptable; Split-halves value revealed 0.487 and 0.660 for first and second halves; and 0.826 for Spearman-Brown Coefficient. From these results, it can be concluded that the remaining 13 items in the section were judged acceptable for information the researcher seeks to elicit.

Validation of BPSOC

This Section contained 12 items on students' process skills in Biology. The responses were scored Excellent, Very Good, Good, Fair and Poor. The KMO value revealed a value of 0.502 which was closer to 1 with p = 0.000 which is appropriate according to Kaiser (1974) and this shows the questions in the listed sections were adequate. This agrees with the minimum standard which should be passed. According to Kaiser (1974) values within 0.5 to 0.6 are good enough and could be used to measure was it was purported to measure. Also revealing a five component rotated matrix, the items could be judged adequate. Items PS4, PS5, PS6, PS3 and PS2 fell under the components 1; items PS7, PS9 and PS10 fell under component 2; items PS2, PS1 and PS11 fell under component 3; while items PS8 and PS10 fell under component 4, only item PS12 fell under component 5. None of the items were removed.

To ascertain the reliability of the-instrument, Cronbach Alpha Reliability, Test-re-test method and Spearman-Brown Coefficient were carried out on the 12 items.

Reliability of BPSOC

The reliability of the-instruments in this section using Cronbach alpha coefficient revealed a factor of 0.627 which is very acceptable; Split-halves value revealed 0.817 and 0.576 for first and second halves. From these results, it can be concluded that the 12 items in the section were judged acceptable for information the researchers seek to elicit.

The instructional package consists of topics on guided inquiry and open inquiry instructional strategy. These treatment instructional packages included were;

(a) Guided Inquiry Strategy (GIS);
(b) Open Inquiry Strategy (OIS);

The topic taught was Basic Ecological Concepts using guided and open instructional strategy. However, with the use of guided inquiry, the students are allow to-investigate questions and procedures that teachers present to them, but the students themselves, through collaborative work decides the processes to be followed to achieved the targeted solution. On the other hand, in open inquiry class, the teacher introduces the knowledge framework in which the inquiry will be conducted, butt allows the students to select a wide variety of inquiry questions and approaches. Thus students-are-engaged in continuous decision-making throughout each stage-of the-open inquiry process, starting from the stage of finding the-interesting phenomenon to be inquired.

The researcher sought for permission from the schools' Principals who then instructed the Biology teachers on how they should assist in carrying out the study. After the permissions from each school, the researcher conducted the pre-test in each school. This served as a baseline for the performance of each student before the treatment was be administered.

The research procedure consisted of three stages, the pre-treatment, treatment and posttest for achievements, process skills and self-efficacy stages respectively. The BPSOC and BSeRC were administered to the students to determine their process skills and self-efficacy in Biology before the treatment was administered. The treatment stages started one week after the pre-test had been administered. The treatment lasted for four weeks based on the schools' 'timetable.

During the experiment, one group received treatment using GIS, the second group received treatment using OIS and the third group was exposed to conventional method. The

experiment was conducted during regular class hours, which consisted of three periods per week (40 minutes each) making a total of 120 minutes weekly for four weeks.

The post-treatment stage started after the treatment stage was over. The post-test BSERS was administered to the three groups, the scripts and questionnaires were collected for marking and coding respectively, before analysis were then carried out on them. The post-test measured the achievement of the respondents in each school. BPSOC determined the students' process skills in Biology after the treatments have been used in teaching them. The Biology process skills were-administered during the practical class of the students. The self-efficacy questionnaire was also administered after the treatments.

Data collected were analyzed using descriptive statistics (mean and standard deviation) and inferential statistics (ANCOVA). The hypotheses were tested using Analysis of Covariance (ANCOVA). Post-Hoc analysis was also carried out where necessary. All hypotheses were tested at 0.05 level of significance.

3. Results:

3.1. Research Hypothesis One: There is no significant difference in the science process skills of students taught Biology using guided inquiry and open inquiry instructional strategies in senior secondary schools in Osun state.

In testing this hypothesis, the science process skills of the respondents was determined by adding the responses of each respondent together before and after the intervention. Analysis of Covariance was then used to determine the difference between the science process skills of the respondents after the use of both strategies for the respondents. The result was presented in Table 2 below.

Table 2: Analysis of Covariance on the Effectiveness of GI and OI on the Science Process Skills of students in the study area.

Tests of Between-Subjects Effects

Dependent Variable: Process Skills Post Test

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	166.892[a]	3	55.631	5.773	0.001	0.121
Intercept	17413.511	1	17413.511	1807.012	0.000	0.935
Process Skills Pre Test	107.881	1	107.881	11.195	0.001	0.082
Group	15.126	2	7.563	0.785	0.458	0.012
Error	1214.216	126	9.637			
Total	321996.000	130				

Corrected Total	1381.108	129

a. R Squared = 0.121 (Adjusted R Squared = 0.100)

Table 2. above revealed that F= 0.785, p>0.05 shows that there is no significant difference in the science process skills of Biology students exposed to Open Inquiry and those exposed to guided inquiry strategy. Hence, the null hypothesis that states that there is no significant difference in the science process skills of students taught Biology using guided inquiry and open inquiry instructional strategies in senior secondary schools in Osun state was not rejected. A partial eta squared value of 0.012 showed that the strategy used accounted for 1.2% variation in the science process skills of respondents in the study area showing that the difference accounted for by the strategy used is minimal.

3.2 Research Hypothesis Two: There is no significant difference in the self-efficacy of students taught Biology using guided inquiry with those taught Biology using open inquiry instructional strategies in senior secondary school in Osun state.

In testing this hypothesis, the self-efficacy of the respondents was determined by adding the responses of each respondent together before and after the intervention. Analysis of Covariance was then used to determine the difference between the self-efficacy of the respondents after the use of both strategies for the respondents. The result was presented in Table 3.

Table 3: Analysis of Covariance on the Effectiveness of GI and OI on the Self-efficacy of students in the study area.

Tests of Between-Subjects Effects

Dependent Variable: Self-Efficacy Post Test

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	987.338[a]	3	329.113	7.782	0.000	0.156
Intercept	3403.360	1	3403.360	80.475	0.000	0.390
Self-Efficacy Pre Test	35.252	1	35.252	0.834	0.363	0.007
Group	984.247	2	492.124	11.637	0.000	0.156
Error	5328.631	126	42.291			
Total	233290.000	130				
Corrected Total	6315.969	129				

a. R Squared = 0.156 (Adjusted R Squared = 0.136)

From Table 3 the result showed that F = 11.64, p < 0.05. This implies that a significant difference existed in the self-efficacy of students taught using GI and OI strategies. Therefore, the null hypothesis that states that there is no significant difference in the self-efficacy of students taught Biology using guided inquiry with those taught Biology using open inquiry instructional strategies in senior secondary school in Osun state is hereby rejected. A Partial Eta Squared value of 0.156 showed that the strategies used accounted for 15.6% variation in the self-efficacy of the students. A Pairwise comparison post-Hoc analysis was then carried out on the two groups to determine the position of the significance difference between the two groups.

Table 4: Post Hoc Analysis of the Effectiveness of GI and OI Strategies on Students' Self-Efficacy

Multiple Comparisons

Dependent Variable: Self-Efficacy Post Test

Scheffe

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
OI	GI	2.4516	1.42956	0.234	-1.0893	5.9925
	Conventional	6.4098*	1.35008	0.000	3.0658	9.7538
GI	OI	-2.4516	1.42956	0.234	-5.9925	1.0893
	Conventional	3.9582*	1.58238	0.047	0.0388	7.8775
Conventional	OI	-6.4098*	1.35008	0.000	-9.7538	-3.0658
	GI	-3.9582*	1.58238	0.047	-7.8775	-0.0388

Based on observed means.

The error term is Mean Square(Error) = 42.235.

*. The mean difference is significant at the 0.05 level.

OI- Open Inquiry

GI- Guided Inquiry

The pairwise posthoc comparison revealed there was a significant difference in the performance of those exposed to open inquiry instructional strategy and those exposed to conventional strategy (p<0.05), while those exposed to open inquiry strategy had better self-efficacy than those exposed to conventional strategies. There was also a significant difference in the effectiveness of the strategies on the self-efficacy of those exposed to guided inquiry and conventional strategies (P<0.05) as those exposed to guided enquiry had better self-efficacy.

4.0 Discussion of Findings

The study sought to examine the comparative effectiveness of open and guided inquiry strategies on science process skills and self-efficacy of Biology students in Osun State. In order to achieve this, objectives were raised and tested.

Result from research hypothesis one found that no significant difference in the process skills of Biology students taught with Guided inquiry and those taught using Open inquiry. This result is in contrast with certain findings which found that the use of open inquiry strategy promotes science process skills of students. For instance, Franklin et al. (2015) discovered among students in the United States that open inquiry strategy promotes a deeper understanding of complex scientific issues, while Schmid and Bogner (2015) found that open inquiry strategy seems to offer enhanced opportunities for cognitive development and scientific reasoning of science students in Germany. However, the findings of Şimşek and Kabapınar (2010) among students in Istanbul showed that inquiry-based learning strategies positively affects students process skills, thus agreeing with this finding.

Result from research hypothesis two found that a significant difference exists in the self-efficacy of students taught using Guided inquiry and those taught using Open inquiry, with those taught using Open inquiry strategy showing a better self-efficacy than those taught using Guided inquiry. This result is consistent with that of Conradty and Bogner (2016) who conducted their study among grade 8 students in Germany. They found that open inquiry strategy promotes the self-efficacy of students when compared to guided inquiry strategy. Plausible reason for this was cited as guided learning only provides short-term effects on knowledge and interest unlike open inquiry strategy which sustain long-term knowledge acquisition, thus increasing students' self-efficacy (Conradty & Bogner, 2016).

5.0 Summary

The study examined the comparative effectiveness of open and guided inquiry strategies on science process skills and self-efficacy of Biology students in Osun State. From the result of the study, there was no significant difference in the science process skills of Biology students exposed to Open Inquiry and those exposed to guided inquiry strategies. A significant difference existed in the self-efficacy of students taught using GI and OI strategies. As those exposed to Open Inquiry had better self-efficacy score than the other groups.

6.0 Conclusion

Based on the outcomes of this study, it was concluded that Open inquiry strategy was more effective in improving the self-efficacy of the respondents but was not effective in improving the science process skills of respondents in the study area.

7.0 Recommendations

Inquiry instructional strategy (especially open inquiry) should be encouraged in teaching science so that learners can learn by themselves and for themselves. Also, learning environment should be conducive for learners to learn innovatively using various inquiry teaching strategies.

Author Contribution

- **Adeyinka Olayemi Owolade** was responsible for data collection**.**
- **Popoola Oluwasegun Oladipupo** wrote the literature review for this study and participated in pattern making and editing. He wrote the draft background section of the paper.
- **Adeyinka Oluwaseun Kareem** was responsible for the analysis and interpretation of the data. He was as well responsible for the validation of the research instruments**.**
- **Marie Onovroghene Salami** oversaw the collection of data and was also involved in the validation of research instruments.

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