Innovations

Effect of Meta cognitive Instructional Strategy Using PEEDA on Biology Students Process Skill Acquisition in Delta State

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Abstract

The study investigated the effect of metacognitive instructional strategy using PEDDA (Prior knowledge, Exploration, Discussion, Dissatisfaction and Application) on Biology student process skill acquisition in Delta State. Three research questions and three hypotheses were tested. The quasi-experimental design, specifically the non-equivalent pretest, posttest, control group design was adopted for the study. The study population was thirty thousand, eight hundred and thirteen (30,813) senior secondary II (SS II) Biology students and four hundred and thirty six (436) public secondary schools, in the three (3) Senatorial Districts of Delta State. A sample of 300 SS II Biology students, and 6 biology teachers randomly selected from six secondary schools in Delta State was used for this study. Science Process Skill Acquisition Test (SPSAT) developed by the researcher was used for data collection. The treatment involved exposing the students in the experimental group to the Biology concepts "pollution, exploration of the different types of pollution, discussion on the causes of pollution as well as the effects of pollution, dissatisfaction with the experience and application of the precautionary measures of pollution", with the use of metacognitive instructional strategy and the reference group employing lecture method. Scores obtained were collated and analyzed using descriptive statistics of average and its deviation, analysis of variance (ANOVA) and analysis of covariance (ANCOVA). It was found in the study metacognitive instructional strategy proved more effective than the lecture method on student process skills acquisition. The study also discovered that there was no discernible difference between male and female students who received instruction in the metacognitive instructional strategy in terms of their mean process skill development scores (PEDDA). Thus, students' mean process skill acquisition scores relative to the teaching methods is not influenced by sex. Based on the findings from the study, it was recommended among others, that the use of metacognitive instructional strategy by Biology teachers during classroom instruction at the secondary school level be adopted to ensure students active involvement.

Introduction

Science and technology are important tools for national development, economic growth and productivity. Science and technology education are the foundations for sustainable national development. According to Abubakar (2012), one of the aims of science teaching is to promote the understanding of concepts being taught with a view to applying knowledge of such understanding to real life situations. The educational policy of the Nigerian Federation (FRN, 2014) placed increased emphasis on scientific literacy. For many years, scientific education at the secondary school level in Nigeria has been steadily declining (Akpokiniovo, 2022).In the light of the foregoing, it is compulsory for all students to offer at least a science subject at the senior secondary school level as stated in the National Policy on Education (NPE, 2014) which Biology is inclusive.

Biology education is important in nation building considering the role it plays in various aspects of the economy and public life such as health, manufacturing, teaching, agriculture, disease and pest control, population control, food production and research. It is critical in many ways for both individual and societal development as seen in biotechnology and genetic engineering (Bena, 2010). The difficulty in learning biological concepts is often reflected in poor process skill acquisition involving these concepts (Ahmed 2008; Nwagbo&Obiekwu 2010). The lecture method is mostly employed by science teachers because it can be used to cover a large class which is a prominent feature in most Nigerian secondary schools. Despite this major advantage, the lecture method has flaws which might be a factor that causes process skill acquisition in biology. All these calls for innovative instructional approaches that are learner-centred and have proved effective during the teaching -learning process and it is capable of maximizing learners' cognitive strategies in knowledge acquisition which involves the individual's meta-cognition

A learning process that is capable of maximizing learners' cognitive strategies in knowledge acquisition involves the individual's meta-cognition (Flavell, 1988). Meta-cognition refers to the cognitive control and monitoring of the first order cognitive processes. Meta-cognitive instructional strategy is an activity based strategy that lays emphasis on active role of learners in the process of constructing their knowledge (Aurah, 2013). Meta-cognitive instructional mechanisms are consistent with the tenets of constructivism. Constructivism takes learning as an active procedure during which students reconstruct knowledge. This learning approach (constructivism) is more concerned in making a shift in instruction from "what are we teaching and how can we deliver it? to "what are the students learning and how do we make sense of what they do. This learning approach offers high opportunity for students' active participation in the learning processes.

Concept mapping, PEDDA (Existing experiences, Exploration, Discussion, Dissatisfaction and Application), framing, Vee-diagram, advanced organizers, and analogies are a few examples of meta-cognitive instructional tactics. This study is however interested only in PEDDA meta-cognitive instructional strategy. This is informed partly by the fact that PEDDA, relative to others, is a new instructional strategy. The 5-steps in PEDDA instructional model are listed sequentially as follows.

- Past experience (P)
- Exploration (E)
- Discussion (D)
- Dissatisfaction (D) and
- Application (A)

Through these steps, PEDDA instructional strategy provides opportunity to expose students' conceptions, test a range of the preconceptions so as to create cognitive encounter in them due to scientific observations (Nworgu, 2006). Thus, this study needs to investigate if PEDDA can influence the science process skill in Biology.

The acquisitions of science process skills are the bases for scientific inquiry and the development of intellectual skills and attitudes that are needed to learn concepts. Ibe (2004) asserted that science process skills are abilities which can be developed by experience and used in carrying out mental and physical operations. According to Ibe (2004), the American Association for the Advancement of Science (AAAS) developed a programme known as 'Science A Process Approach' (SAPA) in the year 2000. This programme sees science processes as true essence of science. The programme was designed to improve children's skills in the process of science. Ajunwa (2000) reported that science educators and curriculum experts modified them by either expanding or condensing them to suit their special needs or expectations. Hence, the Nigerian Educational Research Council changed and developed fifteen (15) science process skills in 1990. These are Observing, Measuring, Classifying, Communicating, Predicting, Inferring, Using number, Using space/time relationship, Questioning, Controlling Variables, Defining operationally, Formulating models, Hypothesizing, Designing experiment and Interpreting data

Realizing the importance of science process skills as solution to scientific problems, the Federal Government, among other things, states as one of the national goals of education in Nigeria that: "education should aim at helping the child in the acquisition of appropriate skills, abilities and competencies, both mental and physical as equipment for the individual to live in and contribute to the development of the society" (Federal Republic of Nigeria (FRN), 2014). To realize this goal, associations, such as Science Teachers Association of Nigeria (STAN) and Nigerian Integrated Science Project (NISP) were set up by the government to oversee the various curricula used at several levels of Nigerian educational system. The various curricula developed, have their objectives which have to be achieved for a successful science education and attainment of the national goals and aspirations. These goals and aspirations cannot be realized except through the effective effort of the classroom teacher. Science process skills help in the stimulation of other skills such as communicative skill, problem solving, decision making, rational thinking and adaptation (Nwosu, 2002). The worth of attainment of science process potetials is necessary for lifelong education, adaptation and for national development. Based on its significance, the expansion of the goal of science education world-wide now includes the acquisition of science process skills which can influence the achievement of students towards Biology (Lawrence, 2006). Al-qaisi (2016) carried out a study to find out the level of achievement in science process skill acquisition of students exposed to the conventional method curriculum and the science inquiry based curriculum and indicated that pupils exposed to inquiry-based curriculum performed significantly better than the pupils exposed to the conventional curriculum that was content oriented in their science process skill acquisition. However, the findings of this study agrees with the work of Ibe (2004) who conducted a study on the effects of guided inquiry and demonstration on science process skills acquisition among secondary school Biology students, when he showed that students exposed to guided-inquiry method perform significantly better relative to those taught using demonstration and conventional method. Moreover, Chukwuemeka (2005) looked at the impact of how material resources were presented on how well primary school students in Enugu State's Nsukka L.G.A. learned science process skills. The findings showed that active engagement by learners in the usage of resources was preferable to the traditional approach for acquiring science process skills. A striking lack of higher-order abilities (analytical and assessment skills) was also demonstrated by Owolabi, Ogunleye, and Adeyemo (2007) among biology students. Research demonstrated that the impact of a metacognitive teaching technique utilizing PEEDA on students' learning of science process skills in biology has not been definitively determined. Would students' learning of process skills in biology be improved by a metacognitive teaching technique employing PEDDA? is the enquiry under study.

Gender was another significant factor this study looked at. The studies of Mandor (2002), who examined the impact of sex and school type on students' biology achievement, show that sex has also remained a topic of concern for educators. Their research revealed that there is disagreement on the impact of gender on the development of scientific processing abilities. Similar to this, Mari (2002) examined how process-based training affected both male and female individuals' development of formal reasoning skills. 38 students were randomly chosen from a secondary school in Kaduna State to examine sex-related variations in the learning of formal reasoning skills. The results revealed that while there was no statistically significant difference in the ability of boys and girls to manipulate variables, the male individuals did noticeably better than their female counterparts. Nevertheless, Shaibu and Mari (2007) conducted research on sex-related variations in junior secondary school students' comprehension of science process abilities in a few Nigerian institutions. In comparison to her male counterpart, the female exhibited a considerably greater comprehension of the processing abilities assessed, according to the study's findings. They also discovered that female pupils were unable to demonstrate their superiority in scientific problem-solving abilities. Research demonstrated that there is no general agreement about how sex affects students' development of biological scientific process skills. The purpose of this study was to ascertain whether there were any differences between male and female biology students who were exposed to PEDDA's metacognitive educational technique.

Research Questions

This investigation was driven by the following set of research questions.

- How do students taught using the PEDDA Metacognitive Instructional Strategy compare to those taught using the lecture teaching approach in terms of mean process skill acquisition scores?
- How do male and female students who were taught using the Metacognitive Instructional Method (PEDDA) vary from one another in terms of their mean scores on the acquisition of process skills?
- What is the interaction effect of teaching strategies (PEDDA, Lecture) and sex on students' process skill acquisition?

Hypotheses

The 0.05 significant threshold was used to test the following hypotheses;

- There is no discernible difference between students taught using the PEDDA (metacognitive instructional strategy) and those taught using the lecture teaching approach in terms of the mean scores on the acquisition of process skills.
- The mean achievement scores of male and female students who received instruction using the metacognitive instructional strategy did not differ significantly (PEDDA).
- There is no discernible interaction impact between teaching methods (PEDDA, lecture) and sex on students' development of process skills.

Materials and Methods

This study used a non-randomized, quasi-experimental pretest-posttest control group design. To the study's utilization of non-randomized intact classrooms, a quasi-experimental design was chosen. The experimental and control groups were chosen at random from among the intact classes, respectively. To maintain the regular class times, the usage of complete courses was required among the independent variables.

Meta-cognitive Instructional Strategy (PEDDA): Lecture style is a governing factor. The Acquisition of Science Process skill scores in Biology are the dependent variables. Sex serves as the moderator variable. Four hundred and thirty six (436) public secondary schools and thirty thousand, eight hundred and thirteen (30,813) senior secondary II (SS II) biology students from Delta State's three (3) senatorial districts made up the study population. For this study, a sample of 300 SS II biology students and 6 biology professors from six secondary schools in Delta State were randomly chosen. The Scientific Process Skill Acquisition Test, one of the key tools created by the researcher and utilized for data collecting (SPSAT).The 40-item SPSAT was created to assess the degree to which students have mastered each science process skill. Items for measuring, experimenting, categorizing, observing, and communicating were dispersed across the process skills. Both the pretest and the posttest were conducted using SPSAT. In order to treat the condition, the experimental group's students were exposed to the biology concepts of "pollution, exploration of the different types of pollution, discussion on the causes of pollution as well as its effects, dissatisfaction with the experience, and application of the control measures of pollution," while the control group received lecture-based instruction.In the interest of deciding if the students comprehended the steps needed in learning science process skills, the biology curriculum was brought to the lab. Using descriptive statistics of mean and standard deviation, analysis of variance (ANOVA), and analysis of covariance, scores were compiled and examined (ANCOVA).

Result Presentation

After each table, the findings are listed and explained in light of the study objectives and accompanying hypotheses.

Research Question 1: How do students taught using the PEDDA Metacognitive Instructional Strategy compare to those taught using the lecture teaching approach in terms of mean process skill acquisition scores?

Table 1: Descriptive statistics showing mean process skill acquisition scores between students taught using Metacognitive Instructional Strategy (PEDDA) and lecture-based instruction

Group	N	Pre test		Mean Difference	Post test		Mean Difference
		Mean	SD		Mean	SD	
Metacognitive Instructional Strategy	150	13.05	2.93	0.11	31.77	3.27	11.93
Lecture Method	150	12.94	3.40		19.84	4.94	

With the metacognitive instructional technique, the pre-test mean process skill acquisition score was 13.05, with a standard deviation of 2.93, and for the lecture method, it was 12.94, with a standard deviation of 3.40. The lecture technique had a mean process skill acquisition score of 19.84 with a standard deviation of 4.94; whereas the metacognitive instructional strategy group received a better mean score of 31.27 with a standard deviation of 3.70. According to Table 1, students who were taught using a metacognitive instructional technique performed better than those who used the lecture method.

Hypothesis 1: There is no discernible difference between students taught using the PEDDA (metacognitive instructional strategy) and those taught using the lecture teaching approach in terms of the mean scores on the acquisition of process skills.

Table 2: Independent sample t- test showing mean process skills acquisition scores between students taught using Metacognitive Instructional Strategy (PEDDA) and lecture-based instruction

Group	N	Mean	SD	df	t-cal	Sig. (2-tailed)	Decision
Metacognitive Instructional Strategy	150	31.77	3.27	298	24.68	0.000	Ho is rejected
Lecture Method	150	19.84	4.94				

P< 0.05

When students were taught biology utilizing a metacognitive instructional technique as opposed to the lecture method, Table 2 demonstrates a significant difference in the mean process skill acquisition scores, with t = 24.68, P = 0.000 0.05. The proposed hypothesis was therefore disproved. As a result, there is a substantial difference between students who were taught biology using a metacognitive instructional strategy and those who were taught using the lecture technique in terms of mean process skills acquisition scores. infavour of teaching metacognitive instructional tools to pupils.

Research Question 2: How do male and female students who were taught using the Metacognitive Instructional Method (PEDDA) vary from one another in terms of their mean scores on the acquisition of process skills?

Table 3: Descriptive statistics showing mean process skills acquisition scores between male and female students taught with Metacognitive Instructional Strategy (PEDDA)

Sex	N	Pre test		Mean Difference	Post test		Mean Difference
		Mean	SD		Mean	SD	
Male	65	13.28	3.07	0.41	32.11	3.32	0.59
Female	85	12.87	2.83		31.52	3.22	

For male students taught using a metacognitive instructional strategy, the mean pre-test process skills acquisition scores were 13.28, with a standard deviation of 3.07; for female students taught using a metacognitive instructional strategy, the mean pre-test process skills acquisition scores were 12.87, with a standard deviation of 2.83. The mean process skills acquisition score for male students taught using a metacognitive instructional method was 32.11, with a standard deviation of 3.32; the mean score for female students taught using a metacognitive instructional strategy was 31.52, with a standard deviation of 3.22. According to Table 9, male students who were taught using a metacognitive teaching technique performed better than their female peers.

Hypothesis 2: The mean achievement scores of male and female students who received instruction using the metacognitive instructional strategy did not differ significantly (PEDDA).

Table 4: Independent sample t- test showing mean process skills acquisition scores of both sexes taught with Metacognitive Instructional Strategy (PEDDA)

Sex	N	Mean	SD	Df	t-cal	Sig. (2-tailed)	Decision
Male	65	32.11	3.32	148	1.10	0.275	Ho is accepted
Female	85	31.52	3.22				

P< 0.05

According to Table 4, there was no discernible difference between male and female students who were taught using the Metacognitive Instructional Method (PEDDA), with a t value of 1.10 and a P(0.275) > 0.05. The null hypothesis was approved as a result. As a result, there is no discernible difference between male and female students who received instruction using the metacognitive instructional strategy in terms of mean process skill development scores (PEDDA).

Research Question 3: What is the interaction effect of teaching strategies (PEDDA, Lecture) and sex on students' process skill acquisition?

Table 5: Descriptive statistics showing interaction consequence of instruction strategies (PEDDA, Lecture) and sex on students' process skill acquisition

Group	Sex	Mean	SD	N
Metacognitive Instructional Strategy	Male	32.11	3.32	65
	Female	31.52	3.22	85
	Total	31.77	3.27	150
Lecture Method	Male	20.17	4.88	75
	Female	19.51	5.01	75
	Total	19.84	4.94	150
Total	Male	25.71	7.31	140
	Female	25.89	7.30	160
	Total	25.81	7.29	300

The mean procedural skill acquisition score for male students who were taught using a metacognitive instructional technique was 32.11, compared to 31.52 for female students, according to Table 5. The average process skill acquisition score for male students who received lectures was 20.17, compared to 19.51 for female students who received lectures. The findings do not point to an ordinal interaction between gender and instructional strategies on the mean process skill acquisition score for students. This was due to the fact that students' mean process skill acquisition scores were greater across all sex levels. Also, this table demonstrates that male students outperformed female pupils in terms of performance.

Hypothesis 3: There is no discernible interaction impact between teaching methods (PEDDA, lecture) and sex on students' development of process skills.

Table 6: ANCOVA statistics on interactive consequences of instruction strategies (PEDDA, Lecture) and sex on students' process skill acquisition

Tests of Between-Subjects Effects						
Dependent Variable: Post-Test						
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	12826.454[a]	4	3206.614	307.094	.000	.806
Intercept	3717.803	1	3717.803	356.050	.000	.547
Pre_Test	2116.631	1	2116.631	202.707	.000	.407
Group	10450.821	1	10450.821	1000.863	.000	.772
Sex	16.723	1	16.723	1.602	.207	.005
Group * Sex	3.783	1	3.783	.362	.548	.001
Error	3080.332	295	10.442			
Total	215702.000	300				
Corrected Total	15906.787	299				
a. R Squared = .806 (Adjusted R Squared = .804)						

Table 6 demonstrates that the development of students' process skills was not affected by the interplay of instructional styles (PEDDA, Lecture). As a result, the null hypothesis was accepted since P (0.548) > 0.05. As a result, there is no discernible relationship between teaching methods (PEDDA, lecture) and sex with regard to students' development of process skills. This suggests that sex has no impact on students' mean process skill acquisition scores in relation to the training approaches.

Discussion of Results

The study's results showed that students who were taught using a metacognitive instructional technique outperformed the lecture method group in terms of acquiring process skills. The study also revealed a significant difference in the mean process skill acquisition scores between students taught biology using a metacognitive instructional approach and those taught using a lecture technique, favouring those taught using the strategy. The chosen methods of instruction may have improved students' understanding of biological ideas more than the others in the area of developing process skills. This implies that the metacognitive instructional technique group's students may have been more engaged in the teaching and learning process, which raised their scores on the acquisition of process skills.This result is consistent with a study by Al-qaisi (2016), which examined the level of achievement in science process skill acquisition among students exposed to a conventional method curriculum and a science inquiry-based curriculum. The study found that students exposed to an inquiry-based curriculum outperformed students exposed to a conventional curriculum that was content-oriented.

In a related development, the study's findings conflict with those of Aurah (2013), who conducted research to assess the value of students using materials and manipulative experiences in the accomplishment of science process? According to the author, students' learning of science process abilities increased most at the lower form of secondary school and slowed at the higher level while using instructional resources made available by SAPA. The outcomes of this investigation, however, are consistent with those of Ibe (2004), who examined the effects of guided enquiry and demonstration on the acquisition of science process skills among secondary school biology students. Ibe found that students exposed to guided-inquiry methods outperform those who are taught using demonstration and conventional methods. Moreover, Chukwuemeka (2005) looked at the impact of how material resources were presented on how well primary school students in

Enugu State's Nsukka L.G.A. learned science process skills. The findings showed that active engagement by learners in the usage of resources was preferable to the traditional way for acquiring science process skills.A striking lack of higher order abilities (operational and assessment skills) was also demonstrated by Owolabi, Ogunleye, and Adeyemo (2007) among biology students.

In a recent study, men students who were taught using a metacognitive instructional technique had higher grades in the acquisition of process skills than their female counterparts. Nonetheless, it was determined from the evidence that the mean process skill acquisition scores of male and female students who were taught using the Metacognitive Instructional Method do not significantly differ from one another (PEDDA). This is demonstrated by the fact that, regardless of the students' sex, metacognitive teaching strategies guaranteed students' active participation during the process of skill development. This result is consistent with that of Ezinwa, who was referenced in Mandor (2002) when she examined how gender and the style of school affected students' biology achievement. Their research revealed that there is disagreement on the impact of gender on the development of science process abilities.The results of this study also agreed with those of Mari (2002), who examined the impact of process-based education on the development of formal reasoning skills in male and female individuals in order to identify sex-related variations in these skills. The results indicated that male respondents fared noticeably better than their female counterparts, yet there was no discernible difference in the ability of boys and girls to manipulate factors. Nevertheless, this study turned the work of Shaibu and Mari (2007), who investigated sex-related disparities in junior secondary school pupils' grasp of science process abilities in several Nigerian institutions.The study's findings indicated that compared to their male counterparts, women understood the process skills examined much better. They also discovered that female pupils were unable to demonstrate their superiority in scientific problem-solving abilities.

According to the study, there was no interplay between teaching methods (PEDDA, lectures) and sex when it came to students' development of process skills. This suggests that sex has no impact on students' mean process skill acquisition scores in relation to the instructional strategies. This result supports Mandor's (2002) research on the impact of sex and school type on students' biology success. The investigation showed that there is no agreement on whether or not sex influences performance in learning science process skills. The findings of this study also support the work of Olagunju (2001), who examined the relationships between sex, age, and biological performance. The study's findings showed there wasn't any discernible difference between male and female colleagues' performance. Because no one's mean score surpassed 40.0%, Shaibu and Mari (2007) found that both boys and girls had an inadequate comprehension of process skills.

Conclusion/Policy Recommendation

The findings imply that a metacognitive instructional strategy based on PEDDA has a stronger effect on students' learning of process skills in biology than the lecture method. Students' development of biological process skills based on sex is unaffected by the PEEDA-based metacognitive teaching technique. As a result, PEEDA's metacognitive instructional style is encouraged for use in secondary school biology classes to help students learn how to process information. Government and education stakeholders should offer adequate physical facilities and instructional resources in order to successfully use the metacognitive teaching approach in secondary school biology classrooms.

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