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Effect of Metacognitive Instructional Strategy Using PEEDA on Biology Students Achievement in Delta State

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ABSTRACT

The purpose of this research was to determine whether and how a metacognitive educational technique based on PEDDA (Prior knowledge, Exploration, Discussion, Dissatisfaction, and Application) will improve the performance of secondary school biology students in Delta State. The investigation was guided by three hypotheses and three research questions. The research used a quasi-experimental design with a non-equivalent pre-post test and control group setup. Students from the public secondary schools in the three (3) senatorial districts of Delta State were included in the research. A total of 30,813 SS II biology students and 436 overall participated. This research employed a sample of 300 SS II biology students and six biology professors from six different high schools in Delta State. Data was gathered using the researcher's primary instrument, the Meta-Cognitive Biology Achievement Test (MBAT). Students in the experimental group were taught the biology concepts of "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 control measures for pollution" using a metacognitive instructional strategy, while students in the control group were taught using the lecture method. Statistical methods such as analysis of variance (ANOVA), analysis of covariance (ANCOVA), and mean and standard deviation (SEM) were used to compile and interpret the results (ANCOVA). It was shown that the metacognitive approach to teaching was more effective than the traditional lecture format. Furthermore, the research indicated that while using the metacognitive teaching technique, there was no statistically significant difference in the mean accomplishment scores of male and female students (PEDDA). The study's results led to many recommendations, including the adoption of metacognitive teaching tactics by secondary school biology instructors to increase student engagement.

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Keywords:
Metacognitive, PEEDA, Instructional Strategy, Achievement, Biology

INTRODUCTION

Studies in biology, one of the sciences, include the observation, classification, and analysis of living organisms. Only in the context of living organisms is it possible to see the myriad of biological processes that make life possible (Nwosu, 2015). The study of biology is the study of life itself; its structure, its functions and their nature, its development, its origins and its interactions with other organisms and their surroundings (Umar, 2011). National development relies on advances in biology-related fields such as medicine, industry, education, agriculture, population control, pest management, food production, and scientific inquiry. As can be observed in the fields of biotechnology and genetic engineering, it plays an essential role in the growth of both individuals and communities (Bena, 2010).

Poor academic performance on tests and exams incorporating biological ideas is a common result of the difficulty of understanding these subjects (Ahmed 2008; Nwagbo & Obiekwu 2010). It's possible that this is due to ineffective classroom practices. Usman (2010) argued that the lecture-only approach currently used to teach biology in secondary schools does not allow for a logical progression of concepts. Because of the huge class sizes typical of secondary schools in Nigeria, lecturing is the primary teaching strategy utilized by science instructors. Despite its

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many benefits, the lecture format has several drawbacks that might be to blame for students' lacklustre performance in biology classes. Students are not put in a position of intellectual growth and agency via hands-on activities during a lecture (Bitrus, 2014). All of this emphasizes the importance of developing novel methods of education that put the student at the centre of the learning experience, have been shown to be effective in the classroom, and are capable of maximizing students' cognitive strategies in knowledge acquisition (a process that requires students to engage in their own meta-cognitive processes).

Teaching using a meta-cognitive approach involves having students actively participate in the construction of their own knowledge, and is therefore an activity-based approach (Aurah, 2013). Learners' alternative notions and their present observation interact to help them create meaning from new information, which is why a meta-cognitive based teaching technique in science acknowledges students' rightful ownership of ideas. Constructivism as an educational philosophy is preoccupied with answering the questions "what are the students learning and how can we make sense of what they do?" rather than "what are we teaching and how can we provide it?" The potential for student engagement in the learning process is enhanced by this instructional strategy.

Concept mapping, PEDDA (Prior knowledge, Exploration, Dissatisfaction, and Application), framing, the Vee-diagram, advanced organizers, and analogies are all examples of meta-cognitive teaching tactics. According to Olayemi (2013), all of these meta-cognitive teaching tactics aid learning by helping students make meaningful connections between their newfound information and previously established ideas. Nworgu's PEDDA is a five-stage method for teaching (2006). It's an approach to teaching based on the study of how people learn, or meta-cognition, and it's designed to help people transform their incorrect beliefs about scientific knowledge. The importance of education and training a child's first ideas about the world are formed by interactions with their surroundings, beginning before birth. This is where the biology of conceptual change comes into play. That is, people come to some kind of realization about the natural world in their own manner. Such ideas or beliefs are often intuitive and at odds with the state of the art in science, making them susceptible to becoming false beliefs. That's according to research (Okebukola, 2002).

Metacognition has a major impact on students' success in biology, says Emenike (2017). This opinion is in line with that of Ayogu (2011), who studied the impact of two meta-cognitive teaching strategies, PEDDA and concept mapping, on high school students' comprehension and use of heat concepts, as well as their general outlook on biology. The study's main takeaways were that both pedagogical approaches improved students' ability to apply the principles of thermal energy and sparked a favorable shift in their attitudes about Biology. A similar study by Yunusa (2010) found that teaching students' metacognitive skills dramatically improved their self-efficacy belief, interest, and success in Biology among low-achieving Biology students in Kogi State, Nigeria.

This investigation also took into account the potentially significant factor of sex. According to Akani (2009), the power dynamics of sex and relationships in most countries are unjustly skewed towards women. Science teachers have long been troubled by students' sexuality. In secondary schools, students of both sexes are expected to take biology as part of their scientific curriculum. However, performance and retention are poor. Multiple attempts have been undertaken by researchers like Achor and Orji (2009) and Ukor (2010) to improve gender parity and women's engagement in learning and development. Gholami (2011) argues that there is no difference in the metacognitive abilities of male and female EFL students. According to Farahani and Nejad's (2008) research, the metacognitive method does not discriminate on the basis of gender while teaching public speaking. Ibe (2004) conducted a study comparing the effectiveness of the inquiry method with the traditional lecture format for teaching senior-level biology, and found that female students outperformed their male counterparts when taught using the inquiry method. This demonstrates that there is no convincing link between the use of metacognitive teaching and sexual orientation. The question driving this research is, then, can students' success in Biology be increased with the use of a metacognitive instructional strategy (PEDDA)? How do students of different sexes perform in Biology classes while employing the metacognitive instructional strategy PEDDA?

RESEARCH QUESTIONS

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

1. What is the difference in the mean achievement scores between students' taught using Metacognitive Instructional Strategy (PEDDA) and lecture teaching method?
2. What is the difference in the mean achievement scores between male and female students taught with Metacognitive Instructional Strategy (PEDDA)?
3. What is the interaction effect of teaching strategies (PEDDA, Lecture) and sex on students' achievement?

HYPOTHESES

The following hypotheses were tested at 0.05 significant level.

1. There is no significant difference in the mean achievement scores between students' taught using

Metacognitive Instructional Strategy (PEDDA) and lecture teaching method.

2. There is no significant difference in the mean achievement scores of male and female students taught with Metacognitive Instructional Strategy (PEDDA).
3. There is no significant interaction effect of teaching strategies (PEDDA, Lecture) and sex on students' achievement.

MATERIALS AND METHODS

Quasi-experimental design, specifically the non-equivalent pre-test, 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 size of 300 SS II Biology students, and 6 biology teachers randomly selected from six secondary schools in Delta State was used for this study. One major instruments developed by the researcher which was used for data collection is the Meta-Cognitive Biology Achievement Test (MBAT). 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 control measures of pollution.", with the use of metacognitive instructional strategy and the control group with lecture method. Scores obtained were collated and analyzed using descriptive statistics of mean and standard deviation, analysis of variance (ANOVA) and analysis of covariance (ANCOVA).

PRESENTATION OF RESULTS

The results are tabulated and interpreted immediately after each table according to the research questions and corresponding hypotheses.

Research Question 1: What is the difference in the mean achievement scores between students taught using Metacognitive Instructional Strategy (PEDDA) and lecture teaching method?

Table 1: Descriptive statistics showing mean achievement scores between students taught using Metacognitive Instructional Strategy (PEDDA) and lecture teaching method

Group	N	Pre test		Mean	Post test		Mean
		Mean	SD	Difference	Mean	SD	Difference
Metacognitive Instructional Strategy	150	13.77	6.15		31.75	3.51	
Lecture Method	150	13.41	3.41	0.36	20.55	5.00	11.20

The result in Table 1 shows the pre-test mean achievement scores of 13.77 and standard deviation of 6.15 for metacognitive instructional strategy and a pre-test mean achievement score of 13.41 and standard deviation of 3.41 for lecture method. For the post-test, the Metacognitive Instructional Strategy group obtained a higher mean score of 31.75 with a standard deviation of 3.51 while the lecture method obtained a mean achievement score of 20.55 and standard deviation of 5.00. Table 1 indicated that students taught with metacognitive instructional strategy scored higher marks than the lecture method group.

Hypothesis 1: There is no significant difference in the mean achievement scores between students taught using metacognitive instructional strategy (PEDDA) and lecture teaching method.

Table 2: Independent sample t- test showing mean achievement scores between students taught using Metacognitive Instructional Strategy (PEDDA) and lecture teaching method

Group	N	Mean	SD	df	t-cal	Sig. (2-tailed)	Decision
Metacognitive Instructional Strategy	150	31.75	3.51	298	22.48	0.000	Ho is
Lecture Method	150	20.55	5.00				rejected

P< 0.05

Table 2 shows that there was significant difference in the mean achievement scores between students taught Biology using metacognitive instructional strategy and lecture method, t = 22.48, P(0.000) < 0.05. Thus, the null hypothesis was rejected. Therefore, there is a significant difference in the mean achievement scores between students taught biology using metacognitive instructional strategy and lecture method in favour of metacognitive instructional strategy.

Research Question 2: What is the difference in the mean achievement scores between male and female students taught with Metacognitive Instructional Strategy (PEDDA)?

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

Sex	N	Pre test		Mean	Post test		Mean
		Mean	SD	Difference	Mean	SD	Difference
Male	65	14.35	8.78		32.26	3.37	
Female	85	13.33	2.81	1.02	31.36	3.58	0.9

The result in Table 3 shows the pre-test mean achievement scores of 14.35 and standard deviation of 8.78 for male students taught with metacognitive instructional strategy and a mean achievement score of 13.33 and standard deviation of 2.81 for female students taught with metacognitive instructional strategy. For the post-test, male students taught with metacognitive instructional strategy obtained a higher mean score of 32.26 with a standard deviation of 3.37 while female students taught with metacognitive instructional strategy obtained a mean achievement score of 31.36 and standard deviation of 3.58. Table 7 indicated that male students taught with metacognitive instructional strategy scored higher marks than their female counterparts.

Hypothesis 3: There is no significant difference in the mean achievement scores between male and female students taught with Metacognitive Instructional Strategy (PEDDA).

Table 4: Independent sample t- test showing mean achievement scores of male and female students taught with Metacognitive Instructional Strategy (PEDDA)

Sex	N	Mean	SD	Df	t-cal	Sig. (2-tailed)	Decision
Male	65	32.26	3.37	148	1.56	0.121	Ho is accepted
Female	85	31.36	3.58				

P< 0.05

Table 4 shows that there was no significant difference in the mean achievement scores of male and female students taught with Metacognitive Instructional Strategy (PEDDA), t = 1.56, P(0.121) > 0.05. Thus, the null hypothesis was accepted. Therefore, there is no significant difference in the mean achievement scores of male and female students taught with Metacognitive Instructional Strategy (PEDDA).

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

Table 5: Descriptive statistics showing interaction effect of teaching strategies (PEDDA, Lecture) and sex on students' achievement

Group	Sex	Mean	SD	N
Metacognitive Instructional Strategy	Male	32.26	3.37	65
	Female	31.36	3.58	85
	Total	**31.75**	**3.51**	**150**
Lecture Method	Male	20.68	5.27	75
	Female	20.41	4.74	75
	Total	**20.55**	**5.00**	**150**
Total	Male	26.06	7.32	140
	Female	26.23	6.88	160
	Total	**26.15**	**7.08**	**300**

Table 5 shows a mean achievement score of 32.26 for male students taught with metacognitive instructional strategy, while their female counterparts had a mean achievement score of 31.36. Male students who were taught with lecture method had a mean achievement score of 20.68 while their female counterpart had a mean achievement score of 20.41. The results do not suggest ordinal interaction between teaching methods and sex on students' mean achievement score. This was because at all level of sex, the students mean achievement score were higher. This table also shows that the male students performed better than their female counterparts.

Hypothesis 3: There is no significant interaction effect of teaching strategies (PEDDA, Lecture) and sex on students' achievement.

Table 6: ANCOVA statistics on interaction effect of teaching strategies (PEDDA, Lecture) and sex on students' achievement

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	10409.005[a]	4	2602.251	168.228	.000	.695
Intercept	15717.696	1	15717.696	1016.102	.000	.775
Pre_Test	957.510	1	957.510	61.900	.000	.173
Group	9155.306	1	9155.306	591.863	.000	.667
Sex	16.829	1	16.829	1.088	.298	.004
Group * Sex	**.186**	**1**	**.186**	**.012**	**.913**	**.000**
Error	4563.245	295	15.469			
Total	220119.000	300				
Corrected Total	14972.250	299				

a. R Squared = .695 (Adjusted R Squared = .691)

Table 6 shows that there was no interaction effect of teaching strategies (PEDDA, Lecture) and sex on students' achievement. P (0.913) > 0.05, therefore, the null hypothesis was accepted. Thus, there is no significant interaction effect of teaching strategies (PEDDA, Lecture) and sex on students' achievement. This implies that students' mean achievement scores relative to the teaching methods is not influenced by sex

DISCUSSION OF RESULTS

The results of the research showed that both the metacognitive instructional technique and the lecture style had a substantial impact on students' performance in biology classes. The research found that students who were taught utilizing a metacognitive instructional style outperformed their lecture-taught counterparts. Table 1 shows that students' posttest performance scores significantly outpaced their pretest achievement scores after therapy. This improvement is due to the treatment's use of a metacognitive pedagogical approach. Therefore, it is reasonable to infer that students' academic performance in biology would improve with the introduction of metacognitive teaching methodologies. This result corroborates the findings of Emenike (2017), who looked at the connection between biology students' metacognition and self-efficacy. The research found that students' levels of metacognition had a substantial impact on their performance in biology classes. This result is in line with the conclusions drawn by Ayogu (2011), who studied the impact of two meta-cognitive teaching strategies, PEDDA and concept mapping, on the practical application of biology ideas and attitudes among secondary school students. The study's primary results were that both pedagogical approaches improved students' ability to apply knowledge of thermal energy principles and prompted a favorable shift in their attitudes about biology. Similar results were found by Yunusa (2010), who studied the impact of teaching metacognitive skills on the self-efficacy, interest, and performance of underachieving biology students in Kogi State, Nigeria. Key results indicated that teaching students' metacognitive abilities greatly improved their biology-related self-efficacy, motivation, and performance.

The study's results showed no statistically significant difference in mean performance scores between male and female students who were given metacognitive teaching methodologies in biology. This data reveals that while teaching biology using a metacognitive approach, both male and female students had similar levels of success. The fact that a metacognitive approach to education guarantees student participation in the teaching and learning process is proof of this claim, and this holds true regardless of the gender of the students. Both male and female students were equally engaged and effective in solving learning problems when taught using the metacognitive instructional technique. Gholami (2011) also showed that there were no differences in metacognitive performance between male and female EFL students; therefore our results are consistent with that study. Furthermore, this result corroborates the findings of Farahani and Nejad (2008), who found that the metacognitive method did not discriminate between the sexes in terms of how they learned to speak. These results, however, are consistent with those of Ibe (2004), who studied the impact of inquiry and lecture methods on the academic achievement of high and low achievers in senior secondary school biology and found that female students performed better than male students among those taught using the inquiry approach.

The research also found that pedagogical approaches (PEDDA, lecture) and sex had no joint influence on students' performance. This indicates that there is no sex difference in the average results of students' performance in

relation to the methods of instruction. The research on gender, age, and performance in biology conducted by Olagunju (2001) is consistent with these results. The research found no statistically significant difference in efficiency between male and female participants. This result is consistent with the conclusions made by Aiyelun (2000), who used 500 students to investigate the impact of sex differences on students' performance in secondary biology (males and females).

CONCLUSION/POLICY RECOMMENDATION

The results suggest that a metacognitive educational technique based on PEDDA has a greater impact on students' performance in Biology than the lecture approach. Students' performance in Biology classes is not affected by students' sex, and neither is it affected by the use of the metacognitive teaching approach PEEDA. Biology instructors at the secondary school level are urged to use the metacognitive instructional method (PEEDA) to increase student engagement. To successfully apply the metacognitive teaching technique in secondary school Biology classes, the government and education stakeholders should provide sufficient infrastructure facilities and instructional resources.

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