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EFFECTS OF PREDICT-EXPLAIN-OBSERVE-EXPLAIN AND VEE HEURISTIC STRATEGIES ON BASIC EDUCATION STUDENTS' METACOGNITIVE AWARENESS IN BASIC SCIENCE IN ANAMBRA STATE, NIGERIA

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ABSTRACT

The study investigated the effects of predict-explain-observe-explain (PEOE) and vee heuristic (VH) strategies on basic education students' metacognitive awareness in Basic Science in Anambra State, Nigeria. Two research questions and three hypotheses were tested at the 0.05 level of significance. The study adopted a pretest-posttest, non-randomized, compare-group quasi-experimental research design. The study's population comprised 2,508 (919 males and 1,589 females) upper basic eight students, offering Basic Science in Awka South Local Government Area. Out of this population, a sample of 49 (12 males and 37 females) students was obtained using a multi-stage sampling procedure. The Basic Science Metacognitive Awareness Scale (BSMAS), adapted from version B of the Junior Metacognitive Awareness Inventory (Jr. MAI) of Sperling et al. (2002), with a Cronbach Alpha reliability coefficient of 0.72, was used to collect data. The instrument was validated by three experts from the Faculty of Education, Nnamdi Azikiwe University, Awka. The data for this study were collected through direct administration of the instrument to the students prior to and after the instructional intervention. The intervention, using the PEOE and VH strategies, lasted for six weeks. The mean, standard deviation, and Analysis of Covariance were used to analyze the collected data. The findings of the study revealed that the students experienced a non-significant gain in their metacognitive awareness, in favour of the VH strategy. The findings also showed that the male and female students exposed to both strategies did not differ significantly in their mean metacognitive awareness scores. The study concluded that the VH strategy enhanced the students' metacognitive awareness in Basic Science more than the PEOE strategy. However, this enhancement was not statistically significant. It was recommended, among other things, that in consideration of their developmental level, Basic Science teachers should provide more time, structured and sustained support when using metacognitive strategies like the PEOE and VH to teach basic education students to enable them become metacognitively aware of their learning process.

Keywords*:* Basic Science metacognitive awareness, compare groups, predict-explain-observe-explain, vee heuristics,

Introduction

Science education is critical for human capital and national development. Its advancement in the 21st century requires learners who are autonomous and self-initiating. This group of learners can be described as being metacognitively aware of their cognition and deploying strategies to learn effectively. The term metacognitive awareness is associated with metacognition, a concept initially introduced by Flavell in 1979. Flavell defined metacognition as an individual's awareness of their learning processes and the application of information to attain specific learning goals. Following Flavell, several other researchers explored the concept and provided analogous definitions. For example, Brown (1987) defined metacognition as an individual's knowledge and regulation of cognitive processes. More recently, Abdelrahman (2020) described the concept as the ability of learners to plan appropriate problem-solving strategies, assess the consequences and outcomes, and adjust approaches based on prior knowledge. The benefits of metacognitive awareness include enabling the learners to recognize and regulate their cognitive processes through self-monitoring and evaluation (Smith *et al.*, 2018; Trisna *et al.*, 2018). Therefore, metacognitive awareness is crucial for enhancing learners' metacognitive skills, which are vital in fostering students' autonomy and 21st century advancement in the area of science education.

Metacognitive awareness refers to the knowledge and regulation of cognitive processes. It encompasses advanced skills that utilize cognitive knowledge to reflect on learning, strategize for learning, monitor the learning process, and assess the effectiveness of one's learning (Mutai, 2015). Abdelrahman (2020) proposed that metacognitive awareness involves students' recognition and evaluation of their cognitive processes and outcomes to minimize errors in problem-solving. The concept is fundamentally categorized into metacognitive knowledge and metacognitive regulation. Abdelrahman defined metacognitive knowledge as the awareness learners have of their cognitive knowledge, which includes both conditional and declarative knowledge. The researcher also defined metacognitive regulation as the processes by which learners improve their memory and learning through the evaluation, monitoring, and planning of their learning activities. Metacognitive knowledge and regulation are crucial for students' learning as they involve information about effective learning strategies for learners. Consequently, students may utilize these strategies to enhance their problem-solving abilities.

Metacognitive awareness is essential in learning, particularly in science education, which is characterized by systematic and procedural approaches. It enables science students to regulate their cognitive processes, resulting in comprehensive achievement (Sutarto *et al.*, 2022). The researchers posited that students who are metacognitively aware of their learning exhibit more strategic and productive learning behaviours, effectively plan their learning, organize tasks, and monitor their progress more efficiently than

those lacking such awareness. The researchers' position corroborated the claims of Abdelrahman (2020), who posited that only students with metacognitive awareness can plan, monitor, regulate, and control their cognitive processes, attitudes, and behaviours, which results in enhanced academic achievement. Similarly, Bajar-Sales *et al.* (2015) posited that only learners with metacognitive awareness can modify ineffective strategies to solve a problem. The modification of strategies indicates that the learner possesses a range of problem-solving strategies, a benefit provided by metacognitive awareness. The assertions indicate that metacognitive awareness enhances student learning by enabling the application of diverse problem-solving strategies.

Considering the importance of metacognitive awareness to science students' learning and knowledge construction, Sutarto *et al.* (2022) proposed emphasizing it from the basic education level, where science subjects, such as Basic Science is taught. Basic Science, now referred to as Basic Science and Technology, based on the revised nine-year Basic Education Curriculum (Nigerian Educational Research and Development Council (NERDC, 2012), is an interdisciplinary subject taught at the basic education level to convey the fundamental unity of scientific thought. Omiko (2016) defines Basic Science as a unified science subject that encompasses studying fundamental concepts in Biology, Anatomy, Earth/Solar system, Ecology, Genetics, Chemistry, and Physics. Basic Science prepares students for the higher sciences. To lay emphasis on the importance of metacognitive awareness at the basic education level require teaching students to become metacognitively aware of their learning. Thus, researchers, including Ajayi (2024) and Ajayi *et al.* (2020), advocate for transitioning from conventional teaching approaches, such as lectures, commonly used in Nigerian science classrooms, to metacognitive strategies such as predict-explain-observe-explain and vee heuristics that enhance students' metacognitive awareness.

The predict-explain-observe-explain (PEOE) strategy is a metacognitive and student-centred teaching strategy that enhances students' metacognitive awareness. According to Ajayi *et al.* (2020), the strategy engages learners in four tasks of "predict, explain, observe, and explain". In the "predict" task, students are presented with information about a concept. These students are expected to predict the outcome based on their prior knowledge. This task allows students to concentrate on observing an experiment or the teacher's demonstration to align their predictions with their observations. It also enhances students' interest and motivation in the lesson. Next is the "explain" task. This task necessitates that, students provide explanations or justifications for their predictions. Through its execution, students' understanding and alternative conceptions of the concept are revealed. This identification is essential for determining students' learning needs and effectively directing instruction to address them. Then, during the "observe" task, the students must observe either their own

conducted experiment or the teacher's demonstration and record essential findings. When executed effectively, this task may generate a conflict in the students' cognition that can be resolved by the teacher. Finally, in the last "explain" task, students engage in a comparative analysis of their predictions and observations to resolve any discrepancies between the two.

Rickey and Stacey (2015) adapted the predict-observe-explain (POE) strategy to prioritize explicit student explanations of their predictions. This focus on students' explanations of their predictions acknowledges the significance of their beliefs in the educational process. Engagement in tasks outlined in the PEOE strategy enhances students' conceptual understanding of scientific knowledge and problem-solving skills, resulting in improved learning outcomes. Rini *et al.* (2019) assert that this teaching strategy enhances learners' understanding of concepts by addressing misconceptions. The strategy accomplishes this enhancement by connecting learners' prior understanding of a concept, whether accurate or inaccurate, to the correct conception.

The vee heuristic (VH) teaching strategy is another metacognitive and student-centred strategy that employs a V-shaped diagram, known as the Vee diagram, to illustrate essential elements or concepts within a specific topic or knowledge structure. The VH strategy was initially proposed by Gowin Vee in 1981. The researcher created the epistemological "V" to assist students in comprehending the structure and process of knowledge construction. The researcher suggested that teachers employ questions to gather knowledge about any concept from students. These questions include: What are the focus questions? What are the fundamental concepts? What methods of inquiry are employed? What are the major knowledge claims? What are the value claims? The vee diagram comprises two components: the theoretical/conceptual side, referred to as the thinking side, located on the right, and the methodological side, known as the doing side, situated on the left. The elements associated with the thinking side encompass worldviews, philosophies, theories, principles, constructs, conceptual structures, statements of regularities or concept definitions, and concepts. The elements on the doing side comprise value claims, knowledge claims (facts), interpretations, explanations, generalizations, results, transformations, and records of events or objects. The events/objects under study are written at the tip of the vee diagram, and the focus questions at the middle link the thinking side to the doing side. The diagram illustrates the relationship between the two sides and the resultant knowledge or value claims.

In employing the VH strategy for teaching and learning, the learner begins by entering the focus question under investigation at the centre of the vee diagram. Subsequently, they document the objects and events required to address the focus question at the tip of the diagram. The learner identifies the theories, principles, constructs, and concepts employed in the study. Methodologically, following the experiment

or the teacher's demonstration, the learner completes the required data in the record and transformation sections. The response to the focus question is detailed in the knowledge claims section, while the significance and relevance of the acquired knowledge are addressed in the value claims section. Upon completing all sections of the vee heuristic diagram, the learner addresses any contradictions between both sides, resulting in a conceptual understanding of scientific knowledge (Ajayi, 2024).

The PEOE and VH techniques facilitate significant and mastery learning by encouraging learners' active engagement in knowledge construction during classroom instruction. Active student engagement in knowledge construction promotes the learning of significant, enduring, and transferable in-depth knowledge. This approach often leads to enhanced learning outcomes for the students (Ajayi and Audu, 2021; Çalis and Özkan, 2022). Additional studies, such those by Ajayi (2024) and Ajayi et al. (2020), indicate that these teaching strategies integrate students' past knowledge or experiences into pertinent knowledge and evaluate their appropriateness. The strategies facilitate the enhancement of cognitive frameworks in learners by linking their pre-existing understanding of a subject to the knowledge they still need to acquire. Coştu and Bayram (2024) contended that these pedagogical tactics allow students to contemplate their scientific viewpoints, therefore promoting the negotiation of both common and novel understandings.

Furthermore, these strategies enable learners to reflect on their cognition, monitor their learning activities, and assess the outcomes of these activities, thereby enhancing their conceptual understanding of scientific concepts and improving their problem-solving skills. Bajar-Sales *et al.* (2015) argued that these teaching strategies cultivate students' awareness of their cognitive processes and enhance their ability to regulate these processes, thereby fostering greater responsibility in their learning development. Coştu and Bayram (2024) also asserted that these teaching strategies prioritize student active classroom engagement. This engagement helps students to construct the meaning of concepts independently. These assertions challenge the prevailing beliefs that science students can become metacognitively aware of their learning without their teachers' intentional application of metacognitive teaching strategies in science classrooms.

Most science classrooms, especially in developing countries like Nigeria are bedeviled with gender-bias and misconception issues. This bias is often influenced by societal stereotypes. These stereotypical perceptions of society have underestimated female students' abilities in science education. According to Musa *et al.* (2018), these perceptions have affected female students' enrollment and achievement in science disciplines. To remedy the situation, the Nigerian government has rolled out several policies, in line with international policy frameworks. One of such policies is the National Policy on Education (FRN, 2013), which advocates equal educational opportunities for all Nigerian children, regardless of gender or other sociocultural

factors. Nevertheless, this stereotypical issue has persisted in Nigerian society and even in science classrooms. Research reports on gender differences in science learning concerning the PEOE and VH teaching strategies have yielded mixed findings. Ajayi and Audu (2021) and Njue *et al.* (2018) found no significant gender differences in students' self-confidence and attitudes toward science, respectively, when employing the PEOE and VH strategies. The researchers described these teaching strategies as gender-responsive. Conversely, other researchers, such as Olalere and Chado (2021) and Musa and Sa'ad (2024) have observed that male students are increasingly becoming the disadvantaged gender in schools. These varying findings necessitated the present study's further investigation on the subject of gender differences in students' learning outcomes, using the PEOE and VH strategies.

Moreover, several studies have been conducted in several locations to ascertain the effectiveness of these strategies in enhancing the metacognitive awareness of older students in Chemistry, Physics, and Biology. Nevertheless, there is a dearth of literature that compares the effectiveness of these strategies in enhancing the metacognitive awareness of younger students in Basic Science in Anambra State. Consequently, the current study is an attempt to fill the gap.

Purpose of the Study

The purpose of this study was to determine the effects of Predict-Explain Observe-Explain (PEOE) and Vee Heuristic (VH) strategies on basic education students' metacognitive awareness in Basic Science in Anambra State, Nigeria. Specifically, the study sought to determine the;

1. effects of the predict-explain-observe-explain (PEOE) and vee heuristic (VH) strategies on upper basic eight students' metacognitive awareness in Basic Science.
2. gender difference in the effects of the PEOE and VH strategies on upper basic eight students' metacognitive awareness in Basic Science.
3. interaction effect of teaching strategies (PEOE and VH) and gender on upper basic eight students' metacognitive awareness in Basic Science.

Methods

Research Design: The study adopted the pretest-posttest non-randomized compare group research design. According to Maciejewski (2020), this type of quasi-experimental research design does not factor in a control group but makes comparison using two experimental groups. The quasi-experimental research design does not permit the random assignment of subjects to experimental groups. Hence, intact classes were used in the study.

Participants: A sample of 49 (12 males and 37 females) upper basic eight education students from two intact classes (PEOE and VH) in two selected secondary schools was used for the study. The sample was drawn from the 2,508 (919 males and 1,589

females) upper basic eight education students in the 19-state government-owned secondary schools in Awka South Local Government Area, using a multistage sampling procedure.

Instrument for Data Collection

The Basic Science Metacognitive Awareness Scale (BSMAS) was used to collect data for the study. The BSMAS was adapted from version B of the Junior Metacognitive Awareness Inventory (Jr. MAI) of Sperling *et al.* (2002). The instrument has two sections. Section A, which seeks to elicit information on the respondents' biodata, and Section B, with a four-point rating scale of Strongly Agree (SA = 4) to Strongly Disagree (SD = 1), which seeks to elicit responses from the respondents on their metacognitive awareness. The instrument was validated by three experts from the Faculty of Education, Nnamdi Azikiwe University, Awka. A reliability of 0.72 was obtained for the instrument, using the Cronbach's alpha reliability technique.

Experimental Procedure: First, the consent of the school authorities, including teachers were sought, and confidentiality was ensured by not including any marker of identification for the students. The consent of the teachers supplemented that of the students' parents (Maduka-Okafor *et al.*, 2022) especially as teachers serve as legal guidance in Nigerian system of education (Nwosu *et al.*, 2023). The research assistants (classroom teachers) administered the BSMAS in the two experimental groups before the treatment (the instructional intervention, using the PEOE and VH strategies) as a pre-test. After the treatment, the items in the instrument were reshuffled and administered as a post-test. The intervention lasted for six weeks.

Data Analysis: The research questions in the study were answered using mean and standard deviation, while the hypotheses were tested at 0.05 alpha level using Analysis of Covariance (ANCOVA). In making decisions, a null hypothesis was rejected if the Probability (P) value is less than or equal to the level of significance ($P \leq 0.05$); if otherwise, the null hypothesis was not rejected.

Results

Table 1: Differences in the Mean Metacognitive Awareness Scores of Students Taught Basic Science using the PEOE and VH Strategies

		Pretest		Posttest		Gain in Mean
Strategies	**N**	**Mean**	**SD**	**Mean**	**SD**	
PEOE	26	56.03	5.28	56.38	5.28	0.35
VH	23	54.13	6.13	54.95	6.40	0.82
Mean Difference		1.90		1.43		0.47

The results in Table 1 show the various means and standard deviations for metacognitive awareness for students taught Basic Science using the PEOE and VH

strategies. From the table, the students taught using the PEOE strategy had mean metacognitive awareness scores of 56.03 and 56.38 in the pretest and posttest, respectively, with a mean gain of 0.35 while their counterparts taught with the VH strategy had metacognitive awareness mean scores of 54.13 in the pretest and 54.95 in the posttest, with a mean gain of 0.82. The result indicated that both strategies slightly enhanced the metacognitive awareness of the students. However, the difference in the mean gain (0.47) for the PEOE and VH strategies revealed that the upper basic eight students taught Basic Science using the VH strategy achieved a higher gain in their metacognitive awareness, compared to those taught using the PEOE strategy.

Table 2: Two-Way ANCOVA Test of Significant Difference between the Mean Metacognitive Awareness Scores of Students Taught Basic Science Using the PEOE and VH Strategies

Dependent: Post-test BSMAS

Source	Type III Sum of Squares	Df	Mean Square	F	P-value	Decision
Corrected Model	1566.855[a]	2	783.427	835.266	.000	
Intercept	.042	1	.042	.045	.833	
PBSMAS	1541.965	1	1541.965	1643.995	.000	
Strategies	2.849	1	2.849	3.038	.088	Not Sig.
Error	43.145	46	.938			
Total	153710.000	49				
Corrected Total	1610.000	48				

a. R Squared = .973 (Adjusted R Squared = .972)

The two-way ANCOVA results from Table 2 show that the F-value is 3.038 and the P-value is 0.088. Since the P-value is greater than the 0.05 level of significance at df 1 and 46, it shows that there is no significant difference between the mean metacognitive awareness scores of students taught Basic Science with the PEOE and VH strategies. Hence, the null hypothesis was not rejected, indicating that both strategies are equivalent in their impact on upper basic eight students' metacognitive awareness.

Table 3: Differences in the Mean Metacognitive Awareness Scores of Male and Female Students Taught Basic Science using the PEOE and VH Strategies

Strategies	Groups	N	Pretest Mean	SD	Posttest Mean	SD	Gain in Mean
PEOE	Male	5	59.80	3.34	60.20	3.36	0.40
	Female	21	55.14	5.31	55.42	5.18	0.28
	Mean Difference		4.66		4.78		0.12
VH	Male	7	53.28	6.57	54.57	6.32	1.29
	Female	16	54.50	6.12	55.12	6.64	0.62
	Mean Difference		1.22		0.55		0.67

The results in Table 3 show the means and standard deviations for metacognitive awareness for male and female upper eight students taught Basic Science using the PEOE and VH strategies. From the table, male students taught using the PEOE strategy had mean metacognitive awareness scores of 59.80 and 60.20 in the pretest and posttest, respectively, with a mean gain of 0.40, while their female counterparts had metacognitive awareness mean scores of 55.14 and 55.42, with a mean gain of 0.28. The difference in the mean gain (0.12) shows that the PEOE strategy was lower in enhancing female students' metacognitive awareness compared to their male counterparts. On the other hand, male students taught Basic Science with the VH strategy had metacognitive awareness mean scores of 53.28 in the pretest and 54.57 in the posttest, with a mean gain of 1.29, while their female counterparts had mean scores of 54.50 and 55.12, with a mean gain of 0.67. The difference in the mean gain (0.67) shows also that the VH strategy was lower in enhancing female students' metacognitive awareness compared to their male counterparts. Overall, the result indicated that male upper basic eight students, compared to their female peers, responded slightly more favourably in metacognitive awareness when taught Basic Science, using the PEOE and VH teaching strategies.

Table 4: Two-Way ANCOVA Test of Significant Difference between the Mean Metacognitive Awareness Scores of Male and Female Students Taught Basic Science Using the PEOE and VH Strategies

Dependent: Post-test BSMAS

Source	Type III Sum of Squares	Df	Mean Square	F	P-value	Decision
Corrected Model	1566.969[a]	2	783.485	837.543	.000	
Intercept	.531	1	.531	.568	.455	
PBSMAS	1540.699	1	1540.699	1647.004	.000	
Gender	2.963	1	2.963	3.168	.082	Not Sig.
Error	43.031	46	.935			
Total	153710.000	49				
Corrected Total	1610.000	48				

a. R Squared = .973 (Adjusted R Squared = .972)

The two-way ANCOVA results from Table 4 show that the F-value is 3.168 and the P-value is 0.082. Since the P-value is greater than the 0.05 level of significance at df 1 and 46, it shows that there is no significant difference in the mean metacognitive awareness scores between male and female upper basic eight students taught Basic Science using the PEOE and VH strategies. Hence, the null hypothesis was not rejected, indicating that both teaching strategies influence metacognitive awareness equivalently for upper basic eight students in Basic Science, irrespective of gender.

Table 5: Two-Way ANCOVA Test of Interaction Effect of Teaching Strategies and Gender on Students' Metacognitive Awareness in Basic Science

Dependent Variable: Post-test BSMAS

Source	Type III Sum of Squares	Df	Mean Square	F	P-value	Decision
Corrected Model	126.193[a]	3	42.064	1.276	.294	
Intercept	112283.000	1	112283.000	3405.250	.000	
Strategies*Gender	126.193	3	42.064	1.276	.294	Not Sig.
Error	1483.807	45	32.973			
Total	153710.000	49				
Corrected Total	1610.000	48				

a. R Squared = .078 (Adjusted R Squared = .017)

The result of the two-way ANCOVA from Table 5 shows that the F-value is 1.276 and the P-value is 0.294. Since the P-value is greater than the 0.05 alpha levels at df 3 and 45, it indicates that there is no interaction effect of teaching strategies and gender on the metacognitive awareness of upper basic eight students in Basic Science, thus the null hypothesis was not rejected.

Discussion

The findings of the study showed that the upper basic eight students taught Basic Science using the PEOE and VH strategies experienced a slight enhancement of their metacognitive awareness after the intervention. However, the observed enhancement was relatively higher in students taught using the VH strategy. From the marginal mean difference between the teaching strategies, it can be asserted that both the PEOE and VH strategies had a comparable effect on the metacognitive awareness of the students. Overall, the non-statistically significant difference finding in the test of hypothesis confirmed that both strategies did not differ in their effects on students' metacognitive awareness. Thus, neither of the strategies demonstrated any significant advantage over the other in enhancing the students' metacognitive awareness.

The findings of this study show a deviation from the findings of previous studies, such as Bajar-sales *et al.* (2015), Ilma *et al.* (2022), who posited that the PEOE strategy and its equivalents, as captured in their studies, significantly improved students' metacognitive awareness in Biology. For the VH strategy, the findings of the study contradict Mutai (2015), who posited that Gowin's Vee significantly improved students' metacognition in the topic of moments in Physics. Furthermore, the findings of the study contradicted the findings of Ajayi and Achor (2021), who posited that both strategies were significant in enhancing students' metacognitive awareness in Chemistry. The non-statistically significant effect of PEOE and VH strategies on upper basic eight students' metacognitive awareness, as captured in the present study, could be because of the level of maturity of the students involved. The present study used younger adolescents in lower secondary school, unlike prior studies that used older

adolescents in senior secondary school. This level of students may be capable of performing varied learning tasks but may struggle to engage in reflective thinking, planning, monitoring, and evaluation of the learning process, which is required for substantial metacognitive growth, as supported by the PEOE and VH strategies. The present study's findings justify the position of Flavell (1979) in his theory of metacognition. Flavel, who may be regarded as the father of metacognition, asserted that the components of metacognition (reflective thinking, planning, monitoring, and evaluation of the learning process) develop with age. This age-related development of metacognition may be the reason why the PEOE and VH strategies did not significantly enhance the metacognitive awareness of the upper basic eight students in the present study. Also, the present study's findings corroborate the assertions of Rickey and Stacey (2015) that metacognitive strategies may not be productive for younger learners' metacognitive awareness of their learning process.

The deviation of the present study's findings from prior findings could also be because metacognitive awareness is a higher-order cognitive construct that often requires sustained, explicit, and structured training. Thus, the short-term instructional interventions used in the study, which focused primarily on Basic Science contents, may not be sufficient to generate noticeable changes in the students' metacognitive awareness. Thus, the students in the present study may not have had enough opportunities to practice the components of metacognition, including reflective thinking, planning, monitoring, and evaluation to experience a significant enhancement in their metacognitive awareness. Also, both strategies may not have significantly enhanced the students' metacognitive awareness because of the emphasis on factual knowledge recall often laid in most Basic Science classrooms. Such emphasis may have affected the significant enhancement of the students' metacognitive awareness of their learning process in the present study. Another probable reason for the present study's findings is increased cognitive load. Since both the PEOE and VH strategies require students' active engagement in the classroom, they also require students to process new information while managing complex tasks, which can lead to cognitive overload, especially for students with weak prior knowledge, and overshadow the opportunity for these students to engage in reflective thinking.

Concerning gender differences in metacognitive awareness, the findings of the study show that male and female students did not benefit equally from the metacognitive demands of the PEOE and VH strategies. For both strategies, the male students experienced a higher gain in metacognitive awareness after the intervention, relative to their female peers. These findings suggest that male learners responded more favourably to both metacognitive teaching strategies than their female counterparts. Despite these observed differences, the hypothesis testing showed that gender had no significant effect on students' metacognitive awareness, meaning that neither of the

strategies gives any advantage to either gender. The present study's observed differences between male and female students' metacognitive awareness and academic achievement, although insignificant, could be because of the confidence and willingness required to externalize thinking processes in metacognitive strategies such as the PEOE and VH. Unlike the female students who may be more cautious, male students tend to verbalize their thinking confidently and willingly, even when uncertain. This advantage may have given them more opportunity to engage with the reflective steps of both strategies. Also, this advantage may have made the male students take more active roles in problem-solving tasks, giving them more practice in monitoring and regulating their thinking during instruction. These advantages over their female peers may have supported their metacognitive awareness better.

The findings of the study agree with Ajayi *et al.* (2024), who posited that there was no significant difference between the mean attention rating and academic performance of male and female students taught Analytical Chemistry using CPEOE, a variant of the PEOE strategy. Similarly, the findings agree with Njue *et al.* (2018), who posited from the findings of their study that the Vee Heuristics Teaching Approach (VHTA) facilitated students' attitudes in Biology irrespective of gender. However, the findings of the study disagreed with Musa and Sa'ad (2024), who posited from their research findings that the heuristic approach is particularly effective in facilitating knowledge retention for female students in Geography than male students. Olalere and Chado (2021) observed similarly that female students performed better than male students when taught Organic Chemistry using the Vee-Mapping Strategy.

For interaction effect, the findings of the study showed that there was no significant interaction effect between teaching strategies and gender on metacognitive awareness. The absence of an interaction effect suggests that the metacognitive demands of both strategies influenced male and female students in similar ways. This finding implies that the metacognitive processes involved in the PEOE and VH strategies, such as prediction, explanations of predictions, self-monitoring, evaluation, and knowledge organization were experienced in the same way by the students, irrespective of their gender. This finding could be because the teacher's instructional approach, classroom structure, and the uniformity of the tasks in each strategy may have provided similar opportunities for male and female students alike.

Conclusion

The study concluded that the vee heuristics (VH) strategy enhanced the metacognitive awareness of the upper basic eight students in Basic Science more than the predict-explain-observe-explain (PEOE) strategy. However, the enhancement was not statistically significant. The study also concluded from the gender-related findings that neither the PEOE nor the VH strategy bestowed any significant advantage to the students based on gender. This conclusion

was drawn based on the non-statistically significant differences observed in male and female students' responses to the metacognitive demands of both strategies.

Recommendations

The following recommendations were made in light of the findings of the study:

1. Basic Science teachers should provide more time, structured and sustained support when using metacognitive strategies like the PEOE and VH to teach younger (upper basic eight) students to enable them become metacognitively aware of their learning process.
2. Basic education students should consciously practice the skills of metacognition to become metacognitively aware of their learning process even though they may not be naturally given to them, considering their developmental level.
3. School administrators should support Basic Science teachers to effectively implement metacognitive teaching strategies such as PEOE and VH for younger students by providing needed resources and organizing seminars and workshops to train the teachers.
4. The Nigerian government should support Basic Science teachers to teach basic education students to become metacognitively aware of their learning. This support can be provided in the form of in-service training for these teachers on the application of metacognitve teaching strategies, such as the PEOE and VH in the classroom

REFERENCES

Abdelrahman, R. M. (2020). Metacognitive awareness and academic motivation and their impact on academic achievement of Ajman University students. *Heliyon*, *6*(9), 1-7.

Ajayi, V. O. (2024). Plan and Implementation of Collaborative Vee Heuristic (CVH) Instructional Approach and Students' Academic Performance in Chemistry. In D. Dias and T. Candeias (Eds). *Academic Performance-Students, Teachers and Institutions on the Stage*. IntechOpen. doi: 10.5772/intechopen.107820

Ajayi, V. O., & Audu, C. (2021). In Search of Viable Pedagogy in Chemistry that could improve students' self-confidence: A Consideration of Predict-Observe-Explain-Elaborate-Write-Evaluate (POE^2WE) or Discussion Strategies? *Kogi Journal of Education and Pedagogy*, *1*(1), 22-31.

Ajayi, V. O., Achor, E. E., & Otor, E. (2020). Effect of organic chemistry pedagogies with PEOE, VH, and discussion strategies on students' achievement in Ekiti State, Nigeria. *International Journal of Education and Learning*, *2*(2), 96-104.

Ajayi, V. O., & Achor, E. E. (2021). Is there any possibility of enhancing students' metacognitive awareness in chemistry in Ekiti state, Nigeria using predict-explain-observe-explain and vee heuristic strategies? A field report. *International Journal of Literacy and Education*, *1*(1), 28-34.

Ajayi, V. O., Negedu, S. A., & Agamber, T. S. (2024). Effect of Gender on Students' Attention and Academic Performance in Analytical Chemistry Using Collaborative-Predict-Explain-Observe-Explain (CPEOE). *Journal of Advanced Research in Education*, *3*(5), 25-35.

Bajar-Sales, P. A., Avilla, R. A., & Camacho, V. M. I. (2015). Predict-Explain-Observe-Explain (PEOE) approach: Tool in relating metacognition to achievement in chemistry. *Electronic Journal of Science Education*, *19*(7), 1-21.

Brown, A. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms". *In* F.E. Weinert and R.H. Kluwe (Eds). *Metacognition, Motivation, and Understanding*, Hillsdale, NJ: Erlbaum.

Çalis, S., & Özkan, M. (2022). The Effect of Science Teaching Based on Poe Strategy on the Academic Achievement and Attitudes of Fifth-Grade Students in the Distance Education Process. *Mimbar Sekolah Dasar, 9*(3), 381-395 DOI: 10.53400/mimbar-sd.v9i3.45472

Coştu, F., & Bayram, H. (2024). From cookbook lab to PEODE-based lab: redesigning lab activities to foster conceptual understanding. *Research in Science & Technological Education*, 1-22.

Federal Republic of Nigeria (FRN, 2013). National Policy on Education. (4th Ed.). Lagos: NERDC Press.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist*, *34*(10), 906-911.

Gowin, D.B. (1981). Educating. Ithaca, New York, NY.: Cornell University Press.

Ilma, S., Al-Muhdhar, M. H. I., Rohman, F., & Sari, M. S. (2022). Promoting Students' Metacognitive Awareness and Cognitive Learning Outcomes in Science Education. *International Journal of Evaluation and Research in Education*, *11*(1), 20-30.

Maciejewski, M. L. (2020). Quasi-experimental design. *Biostatistics & Epidemiology*, *4*(1), 38-47.

Maduka-Okafor, F. C., Okoye, O. I., Oguego, N., Udeh, N., Aghaji, A., Okoye, O., Ezegwui, I. R., Nwobi, E. A., Ezugwu, E., Onwasigwe, E., Umeh, R. E., & Aneji, C. (2022). Recruiting pupils for a school based eye study in Nigeria: Trust and informed consent concerns. Research Ethics, 18(1), 13–23. https://doi.org/10.1177/17470161211045772

Musa, A. B., & Sa'ad, S. M. (2024). Impact of Heuristic Approach on Students' Academic Achievement and Retention in Map Reading and Interpretation Among Secondary Schools, Municipal Zones, Kano-Nigeria. *American Journal of Education and Technology*, *3*(1), 1-8.

Musa, M., Ozoji, E. B., & Duru, V. N. (2018). Vee-Mapping Strategy: A Gender Responsive Technique for Improving Science Achievement. *Interdisciplinary Journal of Gender and Women Development Studies, 1*(2), 175-187.

Mutai, D. K. (2015). *Effects of Gowin's vee heuristic teaching strategy on secondary school students' conceptual understanding and metacognition in the topic of moments in physics, in Uasin Gishu County, Kenya.* Unpublished masters' thesis, Department of Curriculum, Instruction and Educational Management, Egerton University, Njjoro. xii + 112.

Nigerian Education Research and Development Council (NERDC, 2012). *9-year basic education curriculum in Basic Science and Technology.* Abuja: Universal Basic Education Commission.

Njue, A. K., Kamau, L. M., & Mwania, J. (2018). Effects of Vee heuristic teaching approach on secondary school students' attitudes towards Biology in Kenya. *International Organization of Scientific Research Journal of Research and Method in Education*, *8*(1), 18-23.

Nwosu, K. C. Wahl, W. P., Nwikpo, M. N., Hickman, G. P., Ezeonwumelu, V. U., & Akuname, C. C. (2023). School refusal behaviours profiles among Nigerian adolescents: Differences in risk and protective psychosocial factors. Current Psychology, 41 (11),

1-15. https://doi.org/10.1007/s12144-022-03890-6

Olalere, J., & Chado, A. M. (2021). Effects of Computer-Aided Concept-Diagram and Vee-Mapping Strategies on Organic Chemistry Learning Outcome among Senior Secondary School Students in Niger State, Nigeria. *IOSR Journal of Research & Method in Education (IOSR-JRME), 11*(4) Ser. V (Jul. – Aug. 2021), 15-21.

Rickey, D., & Stacey, A. M. (2015). Investigating the effectiveness of a predict-explain-observe-explain-based teaching activity on students' understanding of condensation. *Instruction and Science Journal*, *40*(5), 47-67.

Rini, A. P., Suryani, N., & Fadhilah, S. S. (2019). Development of the predict observe explain (POE)-based thematic teaching materials. *International Journal of Educational Research Review*, *4*(1), 1-7.

Smith, T. R., Smith, J. D., & Beran, M. J. (2018). Not knowing what one knows: A meaningful failure of metacognition in capuchin monkeys. *Animal Behavior and Cognition*, *5*(1), 55-67.

Sperling, R. A., Howard, B. C., Miller, L. A., & Murphy, C. (2002). Measures of children's knowledge and regulation of cognition. *Contemporary educational psychology*, *27*(1), 51-79.

Sutarto, Dwi Hastuti, I., Fuster-Guillén, D., Palacios Garay, J. P., Hernández, R. M., & Namaziandost, E. (2022). The Effect of Problem-Based Learning on Metacognitive Ability in the Conjecturing Process of Junior High School Students. *Education Research International*, *2022*(1), 2313448.

Trisna, B. N., Budayasa, I. K., & Siswono, T. Y. (2018). Students' metacognitive activities in solving the combinatorics problem: the experience of students with holist-serialist cognitive style. In *Journal of Physics: Conference Series* (Vol. 947, No. 1, p. 012072). IOP Publishing.