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ENHANCING BASIC SCIENCE PERFORMANCE AND RETENTION AMONG BASIC EDUCATION STUDENTS IN TARABA STATE NIGERIA: THE IMPACT OF METACOGNITIVE INSTRUCTIONAL STRATEGY USING PEEDA.

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ABSTRACT
This paper explored the impact of the PEEDA metacognitive instructional strategy on Basic Science students' performance and retention in Taraba State. Using a quasi-experimental design, 98 out of a population of 6,288 students were sampled. Data was collected through the Basic Science Performance Test (BSPT) which was adopted from BECE. Descriptive statistics answered research questions, and ANCOVA tested the hypotheses at a 0.05 significance level. Results showed that the PEEDA method significantly improved scores from pre-test to post-test compared to traditional methods ($p<0.05$), although there was no significant difference between male and female students' performance using PEEDA ($p=0.584$). The study concluded that PEEDA enhances basic education student's engagement and comprehension, thereby, recommending its adoption across subjects to improve performance and retention.

INTRODUCTION
The teaching of science involves providing students with opportunities to comprehend a range of concepts and principles while engaging with tangible materials that enhance their understanding. In Nigeria, Basic Science is introduced to pupils and students through the basic education programme during primary education serving as an essential entry point for their scientific education (Danjuma, 2019). This pedagogical approach aims at helping students appreciate the fundamental unity of scientific concepts. Achieving the objectives of Basic Science is a significant priority for education policymakers. One effective method, as noted by Kyado et. al. (2020), is to implement instructional strategies that foster meaningful learning and active participation, enabling students to acquire essential scientific knowledge and skills. This could be achieved through the effective use of metacognitive instructional strategies.

Metacognition encompasses higher-order thinking and involves active control over the cognitive processes that learners engage in while studying (Umaru et.al., 2015). It refers to learners' awareness of their own knowledge and their ability to understand, regulate, and manipulate their cognitive processes. Key metacognitive skills include planning how to approach a learning task, monitoring comprehension, and evaluating progress towards task completion (Akpor, 2017; Alogleh et al., 2019). In problem-solving, metacognition serves as a critical foundation for effectively applying the relevant knowledge and strategies. Important metacognitive skills in problem-solving comprises of planning, monitoring, evaluating, and self-awareness.

Researchers and policymakers have developed various effective teaching strategies for science education, including metacognitive methods like Concept mapping, PEDDA, framing, the Vee-diagram, advanced organizers, and analogies. The PEDDA model, which consists of five steps—Prior conception, Exploration, Discussion, Dissatisfaction, and Application—was created to help learners identify and revise misconceptions in their understanding of scientific knowledge. This instructional strategy focuses on empowering students to construct knowledge by comparing new information with their existing concepts, emphasizing the importance of prior knowledge before introducing new ideas. PEDDA is an instructional strategy designed to empower learners to construct their own knowledge by critically testing their ideas based on prior conceptions (Okotcha et. al., 2023). Students participate in activities that require them to compare the new knowledge they acquire with their existing understandings, ultimately applying these insights to novel situations and enhancing their conceptual grasp. Conversely, various studies have demonstrated that PEDDA can effectively

enhance students' conceptual understanding. Research has shown that implementing PEDDA as a teaching strategy leads to improved cognitive achievement and heightened interest in biology (Ekon & Nwosu, 2016). Furthermore, Okafor et al. (2023) revealed that PEDDA has a more substantial impact on students' performance in biology compared to traditional lecture-based approaches. The PEDDA strategy also fosters valuable opportunities for students to interact with their teacher and engage with one another in the classroom. This method focuses on linking students' existing ideas and beliefs relevant to specific situations while encouraging critical examination of the validity of those ideas and beliefs. PEDDA emphasizes the significance of learners' prior knowledge before introducing new concepts as this could an impact on their performance.

Over the years, student's performance in Basic Science has been alarmingly low. Kyado et al. (2020) noted a substantial decline in both performance and retention among Basic Science students in the Basic Education Certificate Examination (BECE). Similarly, Oguezue and Osuafor (2021) highlighted that despite the essential role of Basic Science within the Nigerian educational curriculum, students continue to struggle in the subject, raising widespread concern among Basic Science educators. Olajide (2012), this challenge may be attributed to the predominance of conventional teaching methods, which have been identified as a significant contributing factor to students' failure and under-performance in the subject. This situation underscores the profound influence that a teacher's chosen instructional approach can have on students' retention of Basic Science concepts.

The ability to retain and recall information is crucial for effective learning. Poor performance in science often results from inadequate knowledge retention, leading to disappointing exam results (Achor & Ukwuru, 2014). According to Michael et al. (2020), improved learning methods enhance retention. When students can remember information from class, their performance in assignments and exams improves. A meta-cognitive teaching approach in science recognizes the importance of students' understanding and ownership of their ideas. As effective as meta-cognitive teaching strategies such as PEDDA is to effective teaching and learning, students' gender could influence their performance and retention in basic science.

The relationship between gender and students' performance in basic science in Nigeria has been a focus of educational research in recent years. Basic science serves as the foundation for STEM education, which is critical for national development. Despite efforts to achieve gender equity in Nigerian education, disparities in performance between male and female students persist, often influenced by cultural, social, and pedagogical factors. A study by Adigun et al. (2018) found no significant gender differences in basic science performance among Nigerian secondary school students. The study concluded that both male and female students can excel in science when provided with equal opportunities and resources. Ogunjimi and Olanrewaju (2021) reported that female students often experience lower self-confidence in tackling scientific problems due to cultural beliefs and the lack of visible female role models in STEM fields. Addressing these issues requires collaborative efforts by educators, policymakers, and communities to create an inclusive and supportive learning environment for all students.

Purpose of Study

The general purpose of his study is to find out the effect of meta-cognitive instructional strategy using PEEDA on basic science students' performance and retention. Specifically, the study sought to:

1. Ascertain the performance of students taught basic science using PEDDA and those taught using conventional strategy
2. Investigate the performance of male and female students taught Basic Science using PEDDA and their counterparts under conventional strategy
3. Identify the retention level of students taught basic science using PEDDA and those taught using conventional strategy
4. Ascertain retention level of male and female students taught Basic Science using PEDDA and those under conventional strategy

Research questions

1. What is the difference between the mean performance scores of students taught basic science using PEDDA and those taught using conventional strategy?
2. What is the difference between the mean performance scores of male and female students taught Basic Science using PEDDA and those under conventional strategy?
3. What is the difference between the mean retention level of students taught basic science using PEDDA and those taught using conventional strategy?
4. What is the difference between the mean retention level of male and female students taught Basic Science using PEDDA and those taught using conventional strategy?

Research Hypothesis

HO_1: There is no significant difference between the mean performance scores of students taught using PEDDA and those taught using conventional strategy

HO_2: There is no significant difference between the mean performance scores of male and female students taught Basic Science using PEDDA and those taught using conventional strategy.

HO_3: There is no significant difference between the mean retention level of students taught using PEDDA and those taught using conventional strategy.

HO_4: There is no significant difference between the mean retention level of male and female students taught Basic Science using PEDDA and those taught using conventional strategy.

METHODOLOGY

Quasi experimental research design was employed for the study. The population of the study is made up of Upper Basic II students in Jalingo Educational Zone with a total of 6,288 students, The Jalingo Education zone is made up of two (2) local government areas, namely; Ardo-Kola and Jalingo. The sample for the study is ninety-eight (98) students from two intact classrooms. The Multi-Stage Random Sampling was used in constituting the Sample for The Study. Jalingo education zone was selected for the study through simple random sampling by using hat and draw technique. A school was selected from each of the two Local Government Areas using purposive sampling. Two intact classes were selected from each of sampled schools and were assigned experimental group and the other Control Group. Basic Science Performance Test was used as the instruments for data collection which was adopted from Basic Education Certificate Examination (BECE). Mean and Standard Deviation was employed to answer the research questions 1-4 while Analysis of Covariance (ANCOVA) was used to test the Null Hypotheses 1-4 At 0.05 level of significance. The use of ANCOVA is considered appropriate for testing of the null hypotheses because it accounts for the initial differences between and within groups which are the covariates that will be obtained from the pre-test data.

Result presentation

Table 1: Mean and standard deviation of students' performances by teaching strategies

Teaching Strategy		Pre-test	Post-test	Mean gain
PEEDA Strategy	Mean	13.72	36.11	22.72
	N	46	46	
	Std. Deviation	2.802	3.459	
Conventional Strategy	Mean	14.04	26.81	12.77
	N	52	52	
	Std. Deviation	2.292	3.260	
Difference				9.95

The table above shows that at pre-test, students in the PEEDA group had a mean performance of 13.72 with standard deviation of 2.80 and at post-test, this means performance increased to 36.11 with standard deviation of 3.46. The students in this group showed a mean gain of 22.72. Students taught using conventional strategy had a mean rating of 14.04 and standard

deviation of 2.29 at pre-test but this figure increased to 26.81 and standard deviation of 3.26 at post-test. This change indicates a mean gain of 12.77.

Table 2: Mean and standard deviation of the performance of students using PEEDA strategy by gender

Gender		Pretest	Posttest	mean gain
	Mean	14.09	36.50	22.41
Male	N	22	22	
	Std. Deviation	2.759	4.229	
	Mean	13.38	35.75	22.37
Female	N	24	24	
	Std. Deviation	2.856	2.609	
Difference				0.04

The table above depicts that at pre-test, male students exposed to PEEDA teaching strategy had a mean performance of 14.09, standard deviation of 2.76 and at post-test, the mean performance increased to 36.50, standard deviation of 4.23. This indicates mean gain of 22.41. Similarly, at pre-test, female students exposed to PEEDA teaching strategy had a mean performance of 13.38, standard deviation of 2.86 and at post-test, the mean performance increased to 35.75, standard deviation of 2.61. This indicates mean gain of 22.37.

Table 3: Mean and standard deviation of students' retention by teaching methods

Teaching Strategy		Post-test	Postpost-test	Mean gain
	Mean	36.11	34.98	1.13
PEEDA Strategy	N	46	46	
	Std. Deviation	3.459	3.269	
	Mean	26.81	23.48	3.33
Conventional Strategy	N	52	52	
	Std. Deviation	3.260	2.437	
Difference				2.2

The table above shows that at Posttest, students in the PEEDA group had a mean performance of 36.11 with standard deviation of 3.46 and at post post-test, the mean performance decreased to 34.98 with standard deviation of 3.27. The students in this group showed a mean loss of 1.13. Students taught using conventional strategy had a mean performance of 26.81 and standard deviation of 3.26 at post-test but this figure decreased to 23.48 and standard deviation of 2.44 at post post-test. This change indicates a mean loss of 3.33.

Table 4: Mean and standard deviation of students' Retention of students using PEEDA strategy by gender

Gender		Posttest	Post posttest	mean gain
	Mean	36.50	34.95	1.55
Male	N	22	22	
	Std. Deviation	4.229	4.270	
	Mean	35.75	35.00	0.75
Female	N	24	24	
	Std. Deviation	2.609	2.064	0.8
Difference				

The table above depicts that at post-test, male students exposed to PEEDA teaching strategy had a mean performance of 36.50, standard deviation of 4.23 and at post post-test, the mean performance decreased to 34.95, standard deviation of 4.27. This indicates mean loss of 1.55. Similarly, at post-test, female students exposed to PEEDA teaching strategy had a mean performance of 35.75, standard deviation of 2.61 and at post post-test, the mean performance decreased to 35.00, standard deviation of 2.06. This indicates mean loss of 0.75.

HO1: There is no significant difference between the mean performance test of students taught using PEDDA and those taught using conventional strategy

Table 5: ANCOVA result of Performance of students taught using PEEDA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2127.229[a]	2	1063.615	94.892	.000
Intercept	2671.695	1	2671.695	238.360	.000
PRETEST	15.712	1	15.712	1.402	.239
GROUPS	**2126.153**	**1**	**2126.153**	**189.689**	**.000**
Error	1064.822	95	11.209		
Total	98427.000	98			
Corrected Total	3192.051	97			

a. R Squared = .666 (Adjusted R Squared = .659)

Table above shows that F (1,95) = 189.68; p = 0.000 < 0.05. This means result of test of significance is lesser than the benchmark 0.05; consequently, the null hypothesis is rejected. This implies that There is significant difference between the mean performance test of students taught using PEDDA and those taught using conventional strategy.

HO2: There is no significant difference between the mean performance scores of male and female students taught Basic Science using PEDDA.

Table 6: ANCOVA result of performance of students in taught using PEEDA strategy by gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	29.899[a]	2	14.950	1.264	.293
Intercept	1877.501	1	1877.501	158.748	.000
PRETEST	23.443	1	23.443	1.982	.166
GENDER	**3.591**	**1**	**3.591**	**.304**	**.584**
Error	508.557	43	11.827		
Total	60515.000	46			
Corrected Total	538.457	45			

a. R Squared = .056 (Adjusted R Squared = .012)

Table above shows that F (1, 43) = 0.304; p = 0.584 > 0.05. This means result of test of significance is higher than the benchmark 0.05; consequently, the null hypothesis is accepted. This implies that There is no significant difference between the mean performance scores of male and female students taught Basic Science using PEDDA.

HO3: There is no significant difference between the mean retention level of students taught using PEDDA and those taught using conventional strategy.

Table 7: ANCOVA result of retention of students in taught using PEEDA

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	3575.375[a]	2	1787.687	390.275	.000
Intercept	139.254	1	139.254	30.401	.000
POSTTEST	348.803	1	348.803	76.148	.000
GROUPS	**318.941**	**1**	**318.941**	**69.629**	**.000**
Error	435.156	95	4.581		
Total	85734.000	98			
Corrected Total	4010.531	97			

a. R Squared = .666 (Adjusted R Squared = .659)

Table above shows that F (1,95) = 69.629; p = 0.000 < 0.05. This means result of test of significance is lesser than the benchmark 0.05; consequently, the null hypothesis is rejected. This implies that There is significant difference between the mean retention level of students taught using PEDDA and those taught using conventional strategy.

HO4: There is no significant difference between the mean retention level of male and female students taught Basic Science using PEDDA.

Table 8: ANCOVA result of performance of students in taught using PEEDA strategy by gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	319.866[a]	2	159.933	42.685	.000
Intercept	19.612	1	19.612	5.234	.027
POSTTEST	319.843	1	319.843	85.364	.000
GENDER	**4.458**	**1**	**4.458**	**1.190**	**.281**
Error	161.112	43	3.747		
Total	56761.000	46			
Corrected Total	480.978	45			

a. R Squared = .056 (Adjusted R Squared = .012)

Table above shows that F (1, 43) = 1.190; p = 0.281 > 0.05. This means result of test of significance is higher than the benchmark 0.05; consequently, the null hypothesis is accepted. This implies that There is no significant difference between the mean retention level of male and female students taught Basic Science using PEDDA.

DISCUSSIONS

The findings in Table 1 highlight significant differences in teaching methods' effectiveness, showing that the PEEDA (Problem Exploration, Explanation, Demonstration, and Application) strategy leads to greater student performance improvements compared to traditional methods. This higher effectiveness aligns with research by González-Hernando et al. (2020) and Kumar and Refaei (2018), which indicates that active and engaging methods enhance critical thinking and knowledge retention. The data indicate a marked performance difference between students taught with PEEDA versus conventional approaches, and the rejection of the null hypothesis confirms its positive impact on student performance, supported by Smith et al. (2019) who noted that active learning fosters engagement and academic success. The performance improvements for both male and female students after using the PEEDA teaching method indicate its effectiveness in enhancing

understanding and application of the subject. The average gain for males and females shows a significant shift in performance from pre-test to post-test, suggesting that the PEEDA strategy benefits both genders equally. There is no notable difference in the average scores of male and female students taught Basic Science with PEDDA, aligning with Barrows (2018), who observed overall improvements without emphasizing gender disparities. Additionally, Zohar and Dori (2018) noted that while active learning is beneficial, subtle differences in learning preferences exist, indicating that females might thrive in collaborative settings, while males may excel in competitive environments.

The PEEDA strategy resulted in higher average post-test scores compared to conventional methods, showing consistent performance over time despite a slight decline. Its effectiveness lies in active learning approaches that enhance engagement and real-life connections (Abubakar et al., 2020). The minor retention loss suggests a more sustainable learning experience than traditional methods, which saw a greater decline. This supports Kizilcec et al. (2020), who noted that passive learning methods hinder higher-order thinking. These findings align with Baepler et al. (2021), emphasizing that active learning leads to better long-term outcomes.

The findings indicate that both male and female students showed good retention using the PEEDA strategy, though female students had a smaller average retention loss compared to males. This may reflect cognitive and behavioral factors related to gender in learning. Previous research suggests that gender differences in learning outcomes can be influenced by teaching methods and individual preferences (Hattie, 2018). However, the results imply that gender does not significantly impact retention with the PEEDA strategy, which emphasizes inclusivity and engagement for all students. Schmid and Petko (2019) note that collaborative approaches reduce gender disparities by promoting shared goals. Ultimately, the PEEDA strategy effectively meets diverse learning needs, benefiting both male and female students through active participation and critical thinking, ultimately fostering equitable learning outcomes.

SUMMARY AND CONCLUSION

The study reveals that the use of PEEDA, a metacognitive instructional strategy, significantly improves basic science students' performance and retention. It shows that PEEDA fosters critical thinking and problem-solving skills, and both male and female students experience similar benefits. Although there was a slight decline in retention, PEEDA still showed superior retention compared to traditional methods. The results support the wider implementation of active learning techniques in educational settings, promoting equitable learning outcomes for all students.

RECOMMENDATION

The following recommendations are derived from the findings of the study:

1. Educators should consider adopting the PEEDA teaching strategy across various subjects to enhance student engagement and performance.
2. Teacher training should prioritize active learning techniques that foster exploration, explanation, and application to further improve student learning outcomes.
3. While the PEEDA strategy is largely equitable, ongoing assessments of gender-related learning preferences can help fine-tune teaching methods and promote even more inclusive learning environments.

REFERENCES

Abubakar, M., Usman, I., & Musa, K. (2020). Enhancing student retention through active learning strategies: A systematic review. *Journal of Educational Research and Practice*, 12(3), 45–56.

Adigun, J. T., Salami, O. O., & Falade, T. A. (2018). "Gender Differences in Students' Academic Performance in Basic Science in Secondary Schools in Nigeria." *Journal of Education and Practice*, 9(3), 45-51.

Akpor, U. (2017). The predictive degree of university students' levels of metacognition and need for cognition on their academic achievement. *European Journal of Foreign Language Teaching*, 2(2), 52-63.

Alogleh, A., Teh, K. S. B. M., Aloqleh, A. M. A., & Mat, K. S. (2019). The effect of metacognition on academic achievement among the Jordanian universities students. *International Journal of Academic Research in Business and Social Sciences*, 9(9), 460-478.

Baepler, P., Walker, J. D., & Driessen, M. (2021). It's not about seat time: Blending, flipping, and active learning in higher education. *Journal of Learning Sciences*, 30(1), 6–27.

Barrows, H. S. (2018). Problem-based learning in medicine and beyond: A brief overview. *New Directions for Teaching and Learning*, *2018*(154), 3-12.

Chen, L., Chen, T.-L., & Lin, Y. (2020). Gender differences in self-regulated learning and academic performance: The mediating role of metacognitive strategies. *Educational Psychology Review*, 32(3), 571–596.

Danjuma.G.S (2019). Science education and sustainable development in Nigeria: an analytic approach. *IOSR Journal of Humanities and Social Science (IOSR-JHSS). 24*(06), 9-34.

Ekon, E.E. & Nwosu, A.A. (2016). Utilizing PEDDA as an effective teaching strategy for better cognitive achievement and interest in biology. *57th Annual Conference Proceedings of Science Teachers' Association of Nigeria,* 410-418.

Freeman, S., Eddy, S. L., McDonough, M., et al. (2019). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 116*(12), 192-197.

González-Hernando, M., Pérez, C., & Rodríguez, J. (2020). The effect of active learning strate gies on students' academic performance. *European Journal of Education Studies, 7*(2), 45-59.

Gopalan, N., Rosinger, K., & Ahn, J. (2018). Traditional versus active learning strategies: A meta-analysis. *Educational Research Review, 25*, 1-17.

Hattie, J. (2018). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement* (Updated edition). Routledge.

Kizilcec, R. F., Saltarelli, A. J., & Reich, J. (2020). Engagement, learning, and retention in online and face-to-face courses: A meta-analysis. *Educational Psychology Review*, 32(4), 443–464.

Kumar, R., & Refaei, B. (2018). Engaging students in critical thinking through active learning strategies. *College Teaching, 66*(4), 213-222.

Kyado, J.J; Achor, E.E and Manasseh, A.F. (2020). Upgrading students' achievement and retention in Basic Science using analogy and demonstration strategies. *CCU Journal of Science, 1* (1), 81-96.

Oguezue N.K. & Osuafor A.M. (2021) Effect of reflective instructional strategy on students' retention in basic science in onitsha education zone. *South Eastern Journal of Research and Sustainable Development. 6*(1), 75-90

Okafor, S.N. Ajaja, O. P, Agboghoroma, T. E. (2023). Effect of metacognitive instructional strategy using PEEDA on biology student's achievement in Delta State. *International Journal of Social Science and Education Research Studies, 3*(1), 25-31

Okotcha, E.N, Eze, P.N & Ewuotu, U.A (2023) Effects of prior conception, exploration, discussion, dissatisfaction and application (PEDDA) model and PEDDA-animated instructional model on achievement of pre-service chemistry teachers'. *International Journal of Research, 10* (6), 178-192

Oladipo, S. E., Adebayo, T. A., & Mohammed, Y. A. (2021). "Regional and Gender Disparities in Science Education in Nigeria: Causes and Implications." *Nigerian Journal of Educational Research*, 10(4), 89-102.

Olajide, J.O (2012). Determination of the level of inquiry teaching and learning taking place in integrated science classroom in Kaduna State. *Journal of Research in Curriculum and Teaching, 6* (1), 466-475.

Schmid, S., & Petko, D. (2019). Gender differences in collaborative learning: Evidence from a meta-analysis. *Journal of Educational Psychology*, 111(5), 795–817.

Umaru, A., Ngwoke, P. U., & Eze, T. I. (2015). Metacognition and academic performance among secondary school students in Nigeria. *International Journal of Educational Research*, 3(2), 45-56.