

Improving Performance via Demonstration-Enriched Team-Pair-Solo Approach: Investigating Ability and Gender Differences among Upper Basic II Students

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Abstract

This study examined the impact of a demonstration-enriched team-pair-solo strategy on academic performance of upper basic II students in Zaria Education Zone, Kaduna State, considering variations in ability levels and gender. Driven by ongoing underperformance in Basic Science and Technology, adopted a pre-experimental one-group pretest-posttest design. Sample consisted of 78 students from a randomly selected coeducational school. Data were collected using the validated Energy Concept Performance Test whose reliability was determined by pilot testing 100 students using test-re-test method and Pearson product-moment correlation coefficient statistic to obtain an index of .76. Data were analyzed using mean and standard deviations for research questions and inferential statistics of ANCOVA and two-way ANOVA at $\alpha = .05$ to test null hypotheses. Ability level had significant impact on posttest performance, $F(2, 75) = 22.886, p < .001, \eta^2_p = .379$, favoring high-ability students. Ability $\times$ Gender interaction was not significant, $F(2, 72) = 1.028, p = .363, \eta^2_p = .028$. In conclusion, Demonstration+TPS improve performance equitably across gender, though high-ability students benefit most. Teachers are encouraged to adopt the strategy for inclusive science instruction.

Keywords: Basic Science and Technology, Demonstration+TPS, varied ability, performance, gender, energy concept

Introduction

Science is the study of natural world through observation, logic and evidence. It represents a systematic exploration of the natural world relying on observation, experimentation and logical reasoning to generate knowledge that addresses societal needs and challenges (Adamu, 2021). It serves as the backbone of technological progress and national development, with core disciplines such as Biology, Chemistry and Physics forming the foundation for careers in Science Technology Engineering and Mathematics (STEM) fields. These subjects are introduced early via Basic Science and Technology (BST), which equips learners with fundamental concepts of energy, matter and environmental interactions (Sakiyo, 2022). Despite its pivotal role, students' performance in BST has consistently remained below expectations (Mgbomo et al., 2024), with failure rates surpassing those

recorded in other school subjects (Oludipe & Oludipe, 2021). Academic performance encompasses cognitive, affective and psychomotor domains which Faniyi (2023) notes may be undermined by ineffective instructional approaches. Demonstration method can address this challenge by engaging learners through observation, participation and practical activities thereby supporting understanding, interest and skill development in science learning.

Demonstration method strengthens comprehension by bridging theory and practice, stimulating interest, enhancing retention and supporting problem-solving (Yousufzai, 2023), but it can encourage passive learning when students remain mere observers. In contrast, the Team-Pair-Solo (TPS) cooperative learning strategy, rooted in Vygotsky's (1978) scaffolding theory, promotes active

participation, peer collaboration and independent mastery (Josiah & Shedow, 2020). Although each approach has proved effective separately, each has limitations in isolation. A Demonstration Team-Pair-Solo (Demonstration+TPS) hybrid combines teacher-led explanation with structured peer interaction and independent practice, providing scaffolding, peer support and gradual release of responsibility in line with contemporary pedagogical frameworks (Hattie, 2023; Kagan & Kagan, 2017; UNESCO, 2021). It is therefore expected to deepen conceptual understanding while accommodating learners of varied ability.

Inclusive classrooms require strategies that address the needs of low-ability (students whose scores are always below an identified pass mark), medium-ability (those whose scores are within an average pass mark) and high-ability learners (those whose scores are above the average pass mark). Low achievers thrive with scaffolding, medium achievers benefit from consolidation and high achievers need enrichment to sustain engagement (Tomlinson, 2017; UNESCO, 2021). In cooperative settings, ability grouping promotes peer support and targeted instruction, thereby enhancing participation and achievement (Olawuwo & Ballo, 2024).

Gender denotes masculinity or femininity in humans; however, this study utilizes the terms male and female. The performance disparity between male and female students in science has been the subject of study over the years, as noted by Babayemi and Robson (2020) and Ani et al. (2021). While these studies found that boys outperform girls at all levels of science education in Nigeria, Eze and Ezenwosu (2024) reported no significant overall differences in academic engagement.

Previous research has validated the efficacy of the demonstration method (Achimugu, 2018; Nnorom, 2017) and TPS (Chiakwelu & Okigbo, 2020; Ogunleye, 2019), these studies have primarily examined them separately rather than as an integrated approach. Research involving learners with diverse abilities (Anyifite, 2024; Huang & Zhu, 2020; Ramos et al. (2021) have focused on peer effects, motivation and science process skills, seldom within inclusive BST classrooms. Moreover, much of the evidence comes from Chemistry, Biology, Physics, Mathematics or general BST at the lower basic or senior secondary levels, leaving the upper basic level understudied. Consequently, little empirical evidence exists on the impact of a Demonstration+TPS hybrid

on the performance of low-, medium- and high-ability students across gender in BST. Hence, this study investigated the effectiveness of Demonstration+TPS in promoting inclusive science learning, focusing on mean performance and the interaction between ability level and gender, guided by two research questions and null hypotheses:

1. What is the difference between the academic performance scores of high, average and low ability students taught energy concepts using Demonstration+TPS strategy?
 2. What is the interaction between ability levels and gender on performance scores of high, average and low ability students taught energy concepts using Demonstration+TPS strategy?
1. There is no significant difference between the academic performance scores of high, average and low ability students taught energy concepts using Demonstration+TPS strategy.
 2. There is no significant interaction on students' performance scores between high, average and low ability and gender when taught energy concepts using Demonstration+TPS strategy.

Literature Review and Theoretical Framework

Bruner's (1961) constructivism and Vygotsky's (1978) social constructivism form the theoretical foundation of Demonstration+TPS. Bruner contended that learners actively build knowledge via guided discovery, emphasizing that learning is most effective when meaningful tasks bridge prior understanding with new experiences. This enhances the effectiveness of demonstrations by allowing students to observe phenomena, explore their significance and independently apply concepts to solve problems. Vygotsky emphasized that learning happens through social interaction and scaffolding within the Zone of Proximal Development, as learners gradually internalize skills to perform them independently. This supports TPS, a framework that advances from team collaboration to paired learning and finally to solo practice, embodying a gradual release of responsibility where knowledge is socially co-constructed before becoming individual. These theories have wide-ranging applications in science education, with Bruner's constructivism shaping inquiry-based learning, discovery methods and demonstrations, while Vygotsky's social constructivism underpins cooperative learning, peer tutoring and scaffolding strategies that prioritize

collaboration and shared meaning-making. Collectively, these theories advocate for a blend of teacher guidance with both collaborative and independent learning, suggesting that merging Bruner's guided discovery with Vygotsky's scaffolding will enhance performance across all ability levels.

Both theories are subject to criticism; Bruner's approach is often viewed as idealistic because it assumes all learners can successfully engage in discovery learning without adequate guidance, potentially putting low-ability students at a disadvantage. Vygotsky's emphasis on social interaction may prove impractical in overcrowded or resource-constrained classrooms, while cooperative learning inspired by his theories risks unequal participation if stronger students dominate the group. Despite this, Bruner's focus on active knowledge construction remains a driving force behind inquiry-based and experiential learning, while Vygotsky's theories form the foundation of modern collaborative and inclusive education. Integrating demonstration with TPS addresses the criticisms by giving learners of all ability levels both structured guidance and opportunities for active engagement.

Empirical Review

Matazu and Kamar (2017) found that activity-based and demonstration methods significantly improved primary students' BST performance compared to traditional teaching approaches. Nnorom (2017) reported that guided inquiry fostered superior science process skills compared to demonstration among biology students, while Achimugu (2018) found that enriched demonstration led to higher chemistry achievement than lecture methods without any gender-based differences. Research on TPS is equally positive. Ogunleye (2019) reported a significantly enhanced chemistry achievement, particularly for extroverted students, while Chiakwelu and Okigbo (2020) found that TPS, jigsaw and reciprocal teaching all improved mathematics achievement, with jigsaw yielding the greatest gains. Josiah and Shedow (2020) noted that TPS equally boosted physics achievement for both male and female students. These results underscore the promise

of demonstration-based and TPS methods for enhancing science learning outcomes.

Research on learners with diverse abilities highlights the importance of inclusive teaching strategies. Huang and Zhu (2020) discovered that a larger share of low-ability students adversely affects peer performance, especially among high achievers, though this negative impact is lessened in well-managed classrooms. Ramos et.al (2021) study found that teacher and peer support strengthened learning goal orientation in both high- and average-ability students, leading to positive long-term outcomes. Anyifite (2024) reported that a science process-based approach enhanced process skills for all ability groups, with high-ability students showing the greatest gains and no gender differences detected. These results highlight the importance of instructional methods that cater to varying ability levels to guarantee fair learning outcomes.

Method

Research Design

A one-group pretest-posttest pre-experimental design (Campbell & Stanley, 1963), which was suitable given the use of intact class and the unavailability of a separate control group, was adopted. The group comprised both male and female subjects. Prior to the treatment, a pretest on Performance was administered to establish their equivalence. Thereafter, subjects were taught energy concepts over a period of six (6) weeks, using Demonstration+TPS strategy. After the treatment, a posttest was administered to find out the impact of Demonstration+TPS on performance of varied ability students in energy concepts.

The study population consisted of 6,684 upper basic II students (3,383 males and 3,301 females) enrolled in 21 coeducational public junior secondary schools within Zaria Education Zone. A single school was chosen via simple random sampling, with 79 students participating. Ability levels were categorized using the Cognitive Abilities Test (Cog-AT; Lohman & Hagen, 2003) into low (0–20), average (21–40) and high (41 and above), enabling comparison of academic performance across ability groups. Table 1 presents the sample distribution.

Table 1
Sample Distribution by Ability Level and Gender

Ability level	Male	Female	Total
Low	8	12	20
Average	15	27	42
High	9	7	16
Total	32	46	78

Note. All students formed a single experimental group. Data were collected in 2025.

Instrument

The Energy Concept Performance Test (ECPT) consisted of 30 multiple-choice questions covering three primary energy topics; Forms, Sources of energy and Energy transformation constructed in line with the revised Bloom's taxonomy to assess various cognitive levels. Each correct answer awarded one point, with a maximum possible score of 30. To ensure content validity, experts from the Departments of Science Education and Physical Sciences at Ahmadu Bello University and the Federal University of Education, Zaria, reviewed ECPT for its administration time, item relevance to study objectives and language appropriateness, with their feedback guiding revisions that strengthened the instrument's validity. ECPT was pilot-tested using test-retest method for an interval of two weeks from first to the second administration and data obtained were analyzed using Pearson product-moment correlation coefficient (PPMCC) yielding a reliability index of .76.

Procedure and Data Analysis

The researchers implemented a six-week treatment that addressed the topics. Subjects were first pretested to establish baseline measures and then categorized by ability level based on their pretest scores. Every lesson consisted of three distinct phases.

During the teacher demonstration phase, instructor introduced the topic, outlined learning objectives and guided subjects through each experimental step using suitable materials while posing guiding questions to engage them. During the collaborative processing phase, subjects completed activities in three stages: first, they worked in heterogeneous groups of five to collectively discuss, observe and perform tasks; second, they collaborated in pairs to repeat activity and solve assigned problems with diminished support; and finally, each subject executed task independently to demonstrate personal mastery. During the feedback and reflection phase, instructor clarified misconceptions, guided subjects to reflect on their learning and reinforced understanding through class and homework. A posttest was conducted at the conclusion of treatment. All procedures were carried out after obtaining approval to conduct the study from relevant educational authority, principal of participating school and the selected students, although they were not informed about classifying them as low-, medium and high ability to avoid any misconception. Data were analyzed using IBM SPSS Statistic (Version 26.0), mean and standard deviations answered research questions and null hypotheses were tested using inferential statistics of Analysis of Covariance (ANCOVA) and two-way Analysis of Variance (ANOVA) at $\alpha = .05$.

Results

Addressing Research Question One

Data generated via ECPT were subjected to descriptive statistic of mean and standard deviation.

Figure 1

Summary of descriptive statistic of post-test performance scores across varied ability levels

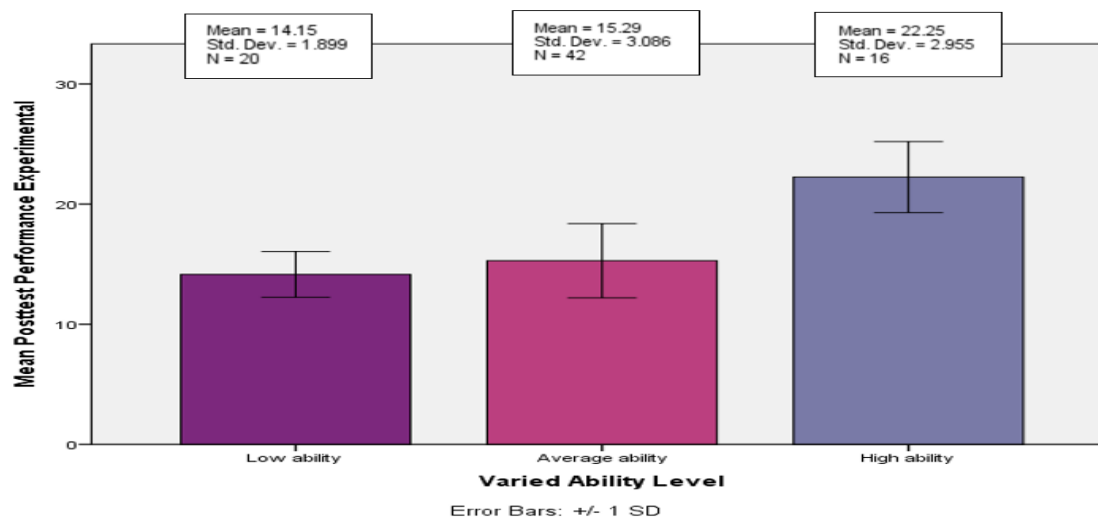


Figure 1 shows the total number of students across varied ability is 78 with 20 students classified as low ability, 42 as average and 16 as high ability. Students in the low-ability group recorded a mean performance score of 14.15 with a standard deviation of 1.899. Those in the average-ability group obtained a mean score of 15.29 and a standard deviation of 3.086. In contrast, students in the high-ability group achieved

the highest mean performance score of 22.25, with a standard deviation of 2.955. The error bars, representing ± 1 standard deviation, illustrate the variability of scores within each ability group. This shows a clear increase in academic performance as students' ability levels rise, with high-ability students outperforming both average and low ability students.

Testing null hypothesis one

Data generated via ECPT were subjected to ANCOVA statistic.

Table 2

ANCOVA using transformed pretest and posttest performance scores across ability levels

Source	Type III Sum of Squares	Df	Mean Square	F-value	p-value	Partial Eta Squared
Corrected Model	14219.464 ^a	2	7109.732	22.886	<.001	.379
Intercept	751.207	1	751.207	2.418	.124	.031
Varied Ability	14219.464	2	7109.732	22.886	<.001	.379
Error	23299.370	75	310.658			
Total	37518.834	78				
Corrected Total	37518.834	77				

a. R Squared = .379 (Adjusted R Squared = .362)

Table 2 indicates a significant difference in posttest performance among the varied ability within the experiment group. Reason been that, the F-value is greater than F- critical and p-value is less than the adopted alpha level of significance $F(2, 75) = 22.886$, $p < .001$. Since the p-value is less than the 0.05 level

of significance, the result suggests that there were significant differences in post-test performance among students with low, average and high ability levels. The partial eta squared value ($\eta^2 = .379$) indicates that approximately 37.9% of the variance in students' posttest performance scores was explained

by differences in ability levels. According to the conventional benchmarks for effect size (.01 = small, .06 = medium, .14 = large), this represents a large effect size. This implies that students' ability level had a substantial influence on their academic performance

after the instructional intervention. Null hypothesis one was thus rejected. Furthermore, Scheffe's post hoc comparison test was conducted to determine which ability groups differed significantly in their posttest performance score as presented in Table 3.

Table 3

Scheffe's post hoc comparison test of performance across ability levels

(I) Varied Ability Level	(J) Varied Ability Level	Mean Difference (I-J)	Std. Error	p-value	95% Confidence Interval	
					Lower Bound	Upper Bound
Low ability	Average ability	-6.895	4.78847977	.360	-18.854	5.064
	High ability	-37.342*	5.91177255	<.001	-52.107	-22.578
Average ability	Low ability	6.895	4.78847977	.360	-5.064	18.854
	High ability	-30.447*	5.17810456	<.001	-43.379	-17.515
High ability	Low ability	37.342*	5.91177255	<.001	22.578	52.107
	Average ability	30.447*	5.17810456	<.001	17.515	43.379

Based on observed means.

The error term is Mean Square (Error) = 310.658.

*. The mean difference is significant at the .05 level.

Result in Table 3 reveals no statistically significant difference between students with low and average ability ($MD = -6.895, p = .360$). This indicates that the post-test performance of students in the two ability groups was relatively similar when taught using demonstration+ TPS. However, a significant difference was observed between students with low

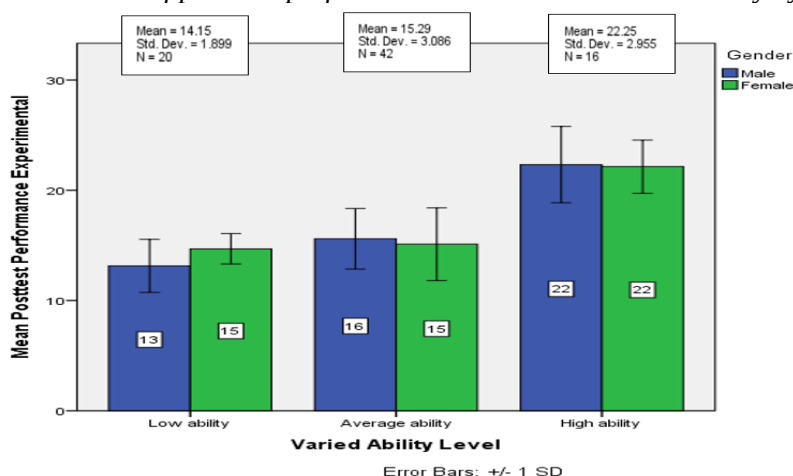
and high ability ($MD = -37.342, p < .001$). The negative mean difference indicates that students in the high-ability group achieved significantly higher post-test performance scores than students in the low-ability group. Similarly, students with average ability performed significantly lower than those with high ability ($MD = -30.447, p < .001$).

Addressing Research Question Two

Data generated via ECPT were subjected to descriptive statistic of mean and standard deviation.

Figure 2

Descriptive statistic of post-test performance scores across varied ability by gender



Descriptive statistic in Figure 2 shows the mean posttest performance scores of students across different ability levels and gender categories. Results indicate that students in the high-ability group recorded the highest mean ($M = 22.25$, $SD = 2.96$), followed by those in the average group ($M = 15.29$, $SD = 3.09$), while students in the low ability group obtained the lowest mean ($M = 14.15$, $SD = 1.90$). Within the low-ability category, female students

achieved a slightly higher mean ($M = 15$) than male students ($M = 13$). In the average-ability group, male students recorded a marginally higher mean score ($M = 16$) compared to females ($M = 15$). For the high-ability group, both male and female students have similar performance scores ($M = 22$). The result shows that students' posttest performance gender differences were minimal across the groups when taught using demonstration+ TPS.

Testing Null Hypothesis Two

Data generated via ECPT was subjected to Two-Way ANOVA.

Table 4

Two-Way ANOVA of interaction of varied ability and gender on performance

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Squared	Eta
Corrected Model	14999.445 ^a	5	2999.889	9.591	<.001	.400	
Intercept	554.473	1	554.473	1.773	.187	.024	
Varied Ability	14668.746	2	7334.373	23.450	<.001	.394	
Gender	346.848	1	346.848	1.109	.296	.015	
Varied Ability * Gender	643.226	2	321.613	1.028	.363	.028	
Error	22519.389	72	312.769				
Total	37518.834	78					
Corrected Total	37518.834	77					

a. R Squared = .400 (Adjusted R Squared = .358)

Result in Table 4 shows no significant difference in performance scores between male and female students within the group. Reason been that the F-value is less than F- critical and the p-value is greater than the adopted alpha level of significance $F(1, 72) = 1.109$, $p = .296$, $\eta^2 = .015$, indicating no significant difference between male and female students. Similarly, the interaction effect between varied ability and gender was not significant, $F(2, 72) = 1.028$, $p = .363$, $\eta^2 = .028$, suggesting that the influence of ability level on performance did not vary by gender. Consequently, null hypothesis two is not rejected.

Discussion

Result in Table 2 showed that Demonstration+TPS strategy had a significant effect on the academic performance of students across ability levels. This indicates that students' ability level influenced how effectively they benefited from the instructional strategy. The post hoc analysis result in Table 3 revealed no statistically significant difference between students with low and those with average ability, suggesting that both groups benefited from

Demonstration+TPS strategy to a similar extent. However, a significant difference was observed between students with low and those with high ability, with high-ability students achieving better performance. Likewise, students with average ability performed significantly lower than students with high ability, indicating that high ability students derived greater academic benefits from the instructional strategy than their low and average ability counterparts. This may indicate that they were more cognitively prepared to capitalize on the learning opportunities offered by the strategy, whereas the lack of difference between low- and average-ability students suggests that the strategy provided adequate support for both groups to achieve similar results. This finding aligns with the results reported by Ramos et al. (2021) that high-ability students generally outperform their low- and average-ability peers due to their prior knowledge, reasoning skills and learning readiness.

Result in Table 4 showed that Demonstration+TPS had no significant effect on the academic performance of low, average and high ability male and female students taught energy concept. The lack of a significant ability and gender

interaction indicates that the strategy's effectiveness remained consistent across ability levels and genders, with both male and female students benefiting equally within each ability category. Despite variations in performance across ability groups, gender had no effect, indicating that Demonstration+TPS offers equitable learning opportunities and is gender indifferent. This aligns with Johnson et al (2021) who found that cooperative learning strategies generally benefit students of all genders by emphasizing collaboration, shared responsibility and active participation. Overall, the strategy promote stronger learners while offering sufficient scaffolding and peer support for weaker ones, thereby demonstrating its potential to advance inclusive learning by narrowing achievement gaps across gender and ability levels.

It is important to recognize several limitations. The study's limited generalizability stems from its focus on just one coeducational school within Zaria Education Zone, Kaduna State, and its sample of 78 students, which, while sufficient for an experimental design, represents only a small fraction of the population. Because it addressed only energy concepts within BST, the effectiveness of this approach for other science topics has not yet been evaluated. The ability classification depended on a single standardized test (Cog-AT) and pretest scores used, which may fail to capture the multidimensional nature of ability. Finally, the pre-experimental one-group design lacks a control group and thus cannot establish causality.

Implications and Recommendations

Theoretically, these findings support Bruner's (1961) constructivist theory and Vygotsky's (1978) social constructivist framework by demonstrating that integrating guided discovery with scaffolding and collaboration improves conceptual understanding and performance, while also providing empirical evidence for incorporating demonstration and cooperative learning into BST classrooms. In practice, teachers could integrate the Demonstration+TPS approach for teaching complex science topics like energy, combining teacher-led explanations with peer collaboration and independent practice to foster deeper understanding and narrow achievement gaps. Curriculum planners and policymakers must integrate cooperative demonstration strategies into teacher training programmes for junior secondary schools, while schools themselves should ensure the provision of sufficient resources and classroom management

support. Future studies should utilize larger, multi-site randomized controlled trials to enhance causal inference and explore applications across other scientific disciplines.

Conclusion

This study examined the impact of Demonstration+TPS on the academic performance of upper basic II students, analyzing differences across ability levels and gender. The strategy improved performance, with ability level having a substantial impact on posttest results, as high-ability students outperformed both low- and average-ability students, indicating that the scaffolding was adequate for both groups. The Demonstration+TPS approach is gender indifferent and promotes equitable learning opportunities.

Declarations

Ethical Statement: This study adhered to ethical principles governing research with human participants. School authorities granted permission, participants and their guardians provided informed consent, confidentiality was upheld and participants were informed of their right to withdraw at any time without penalty.

Conflict of Interest: The authors declare that they have no financial or non-financial conflicts of interest.

Author Contributions: Adamu Abdullah conceived the study, designed the methodology and supervised the research. Safiya Shafiu Muhammed contributed to the literature review, data collection and instrument development. Aliyu Abdullahi contributed to data analysis and the preparation of the manuscript. All authors have approved the final manuscript.

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Data Availability: The data are available from the corresponding author upon reasonable request.

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