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Impact of Team-Pair-Solo Instructional Strategy on Students' Engagement and Performance in Construction Concepts in Zaria Education Zone Kaduna State

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Abstract

This study investigated the impact of Team-Pair-Solo (TPS) instructional strategy on students' engagement and performance in construction concepts in Zaria Education Zone, Kaduna State. The study was guided by four objectives, research questions, and hypotheses. A quasi-experimental pre-test, post-test, non-equivalent control group design was adopted. The population comprised students in 62 public senior secondary schools, while 132 students were selected as the sample. Two intact classes were assigned to experimental and control groups. The experimental group was taught using TPS, while the control group received conventional instruction. Data were collected using the Construction Performance Test (CPT) and Construction Engagement Scale (CES), validated by three experts. Reliability coefficients of 0.88 and 0.79 were obtained using Kuder-Richardson Formula 21 (KR-21) and Cronbach's alpha, respectively. Mean and standard deviation answered the research questions, while Analysis of Covariance (ANCOVA) tested the hypotheses at the 0.05 significance level. Findings revealed that students taught using TPS demonstrated higher engagement and better performance than those taught conventionally. No significant gender differences were found in engagement or performance. The study recommended adopting TPS and organizing teacher training workshops on student-centred instructional strategies.

Keywords: team-pair-solo, performance, engagement, construction concepts, gender

1 Introduction

Mathematics is regarded as the bedrock of science and technology. It plays a vital role in national development by equipping learners with analytical, logical, and problem-solving skills necessary for survival in a technological world (FRN, 2013). Within the secondary school mathematics curriculum, Construction is one of the major topics in Geometry. It involves the use of mathematical instruments such as compass, ruler, and protractor to accurately draw geometric figures, bisect angles and lines, and construct triangles, quadrilaterals, and circles (WAEC, 2022). Despite its importance, students' performance in Construction has remained consistently poor over the years. Reports from the West African Examinations Council (WAEC, 2026) indicate that candidates continue to record low scores in questions related to Construction. Chief examiners' reports have attributed this poor performance to students' inability to follow sequential steps, lack of understanding of geometric concepts, poor use of mathematical instruments, and over-reliance on rote memorization (WAEC, 2026). In Kaduna State, and particularly in Zaria Education Zone, similar trends have been observed. Many students find Construction abstract and difficult because the conventional method does not provide them with adequate opportunity to explore, discuss, and practice the concepts collaboratively. The poor performance in Construction has serious implications. It affects students' overall achievement in Mathematics and further limits their chances of pursuing science, engineering, and technical courses at tertiary level. This situation calls for the adoption of more effective instructional strategies that can improve students' understanding, performance, and engagement in Construction. In recent times, mathematics educators have advocated for instructional strategies that promote active learning and student participation. One of such strategies is the Team-Pair-Solo (TPS) instructional strategy.

TPS is a cooperative learning approach developed by Spencer Kagan (1994). It is a three-stage process in which students first work in Teams to brainstorm and discuss a problem, then work in Pairs to solve it collaboratively, and finally work Solo to attempt the problem independently (Kagan, 1994). The strategy is designed to build confidence, promote peer interaction, and gradually shift responsibility from the teacher to the learner. The rationale for teaching problem solving, and by extension Construction, through TPS is anchored on the fact that students learn better when they are actively engaged and given opportunities to explain their thinking to others (Vygotsky, 1978). TPS provides scaffolding: students receive

support in Teams, refine understanding in Pairs, and demonstrate mastery in Solo. This approach aligns with Polya's (1945) problem-solving model which emphasizes understanding the problem, devising a plan, carrying out the plan, and looking back. Studies have shown that cooperative learning strategies like TPS improve academic performance, retention, and students' engagement in Mathematics (Ajai & Imoko, 2015; Yusuf, 2021). However, most of these studies have focused on general mathematics topics such as Algebra and Statistics. There is a paucity of research on the impact of TPS on students' performance and engagement specifically in Construction concepts, particularly within the context of Zaria Education Zone, Kaduna State. Zaria Education Zone comprises several public secondary schools with diverse student populations. Many of these schools still rely on the traditional teacher-centred method which limits student participation. Given the documented challenges in Construction and the potential benefits of TPS, it becomes imperative to investigate how this strategy can improve students' performance and engagement in Construction concepts in Zaria Education Zone.

Students' Performance refers to students' academic achievement as measured by test scores (Akinsola, 2008). In this study, performance is measured by students' scores in the Construction Performance. Students' Engagement refers to students' behavioural, emotional, and cognitive involvement in learning activities (Fredricks, Blumenfeld & Paris, 2004). Behavioural engagement includes participation and attention. In this study, engagement is measured using an observation rating scale during Construction lessons. Several studies have investigated cooperative learning strategies in mathematics. Ajai and Imoko (2015) investigated the effect of TPS on students' achievement in Algebra in Makurdi, Benue State. They found that students taught with TPS performed significantly better than those taught with lecture method. Yusuf (2021) examined the effect of TPS on students' engagement in Mathematics in Ilorin, Kwara State. The study revealed that TPS significantly improved students' participation and interest in Mathematics lessons. Akinsola (2018) studied gender differences in cooperative learning and found no significant difference between male and female students' performance when taught with cooperative strategies. However, there is limited literature on the use of TPS specifically for Construction concepts in secondary schools, and none in Zaria Education Zone, Kaduna State. This gap justifies the present study. From the review, it is evident that problem solving is central to mathematics learning and that instructional strategies that promote active participation improve performance and engagement. TPS has been found effective in other mathematics topics, but its impact on Construction in Zaria Education Zone has not been empirically established. This study therefore seeks to fill that gap.

1.1 Statement of the Problem

Students' performance in Construction in Senior Secondary School Certificate Examinations has been persistently low. In Zaria Education Zone, teachers report that students struggle with accuracy, sequencing of steps, and application of Construction concepts. The predominant lecture method does not encourage students to think critically, collaborate, or take responsibility for their learning. Consequently, many students develop negative attitudes toward Construction and Mathematics in general. While several instructional strategies have been recommended to address this problem, there is limited empirical evidence on the effectiveness of Team-Pair-Solo instructional strategy in improving students' performance and engagement in Construction within Zaria Education Zone. It is against this background that this study seeks to investigate the impact of Team-Pair-Solo instructional strategy on students' performance and engagement in Construction concepts in Zaria Education Zone, Kaduna State, Nigeria.

1.2 Objectives of the Study

The main purpose of this study is to determine the impact of Team-Pair-Solo instructional strategy on students' performance and engagement in Construction concepts in Zaria Education Zone, Kaduna State. Specifically, the study intends to:

1. Investigate the effect of TPS on students' engagement during Construction lessons.
2. Determine the effect of TPS on students' performance in Construction concepts.
3. Investigate whether there is any significant difference in the engagement of male and female students taught Construction using TPS.
4. Investigate whether there is any significant difference in the performance of male and female students taught Construction using TPS.

1.3 Research Questions

This study was guided by the following research questions:

1. What is the effect of Team-Pair-Solo instructional strategy on students' engagement during Construction lessons in Zaria Education Zone?
2. What is the effect of Team-Pair-Solo instructional strategy on students' performance in Construction concepts in Zaria Education Zone?
3. Is there any significant difference in the engagement of male and female students taught Construction concepts using Team-Pair-Solo instructional strategy?
4. Is there any significant difference in the performance of male and female students taught Construction concepts using Team-Pair-Solo instructional strategy?

1.4 Research Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance:

Ho_1: There is no significant difference in the mean engagement scores of students taught Construction concepts using Team-Pair-Solo instructional strategy and those taught using the conventional method.

Ho_2: There is no significant difference in the mean performance scores of students taught Construction concepts using Team-Pair-Solo instructional strategy and those taught using the conventional method.

Ho_3: There is no significant difference in the mean engagement scores of male and female students taught Construction concepts using Team-Pair-Solo instructional strategy.

Ho_4: There is no significant difference in the mean performance scores of male and female students taught Construction concepts using Team-Pair-Solo instructional strategy.

2 Methodology

This study adopted a quasi-experimental of pre-test, post-test, non-equivalent control group design. The design is considered appropriate because the subjects already exist in intact classes and random assignment of individual students is not possible in school settings (Creswell, 2014). The population of the study consists of (7,870) SSII Mathematics students in public Senior Secondary Schools in Zaria Education Zone, Kaduna State. The sample for this study comprised of 132 SSII Mathematics students from 2 intact classes in 2 co-educational public secondary schools in Zaria Education Zone. Purposive sampling and Simple random sampling techniques was used to select 2 schools that have qualified Mathematics teachers and facilities for teaching Construction. Simple random sampling techniques was used to assign one school as Experimental group and the other as Control group. Intact classes were used to avoid disruption of normal school activities. Two instruments were used for data collection namely Construction Performance Test (CPT) this is a 20-item test developed by the researcher. It consists of 20 objective questions and 3 essay questions drawn from SSII Construction topics: bisection of lines and angles, construction of triangles, quadrilaterals, and circles. The CPT was used as both pre-test and post-test. Maximum score 40 marks. Construction Engagement Scale (CES). This is a 15-item, 4-point linker scale adapted by the researcher. Two sets of lesson plans were developed, one based on TPS for the experimental group and one based on conventional method for the control group. Both covered the same Construction content for 6 weeks. The face and content validity of CPT and CES were determined by 3 experts: 2 from Mathematics Education Department, Ahmadu Bello University Zaria and 1 experienced SS II Mathematics teacher. Their corrections and suggestions were incorporated. The reliability of CPT was determined using Kuder-Richardson 20 (KR-20) and a coefficient of 0.88 was obtained. The reliability of CES was determined using Cronbach Alpha and a coefficient of 0.79 was obtained. Both values are considered reliable for this study. Descriptive statistic of mean and standard deviation was used to answer research questions while inferential statistic of ANCOVA was used to test the null hypotheses at 0.05 level of significance.

Steps in Using Team-Pair-Solo (TPS) Instructional Strategy in Teaching Construction Concept

Team-Pair-Solo was developed by Spencer Kagan, 1994. It's a 3-stage cooperative learning strategy that moves students from group support to independence. Perfect for Construction because students practice with help before doing it alone.

The 3 Steps of TPS for Teaching Construction are:

STAGE 1: Team Goal: Learn together with teacher guidance and peer support Group Formation, divide students into heterogeneous teams of 4-5 students. Mix high, average, and low achievers and mix gender. Teacher demonstrates the construction concept. For instance: "Construction of a 60° angle using compass and ruler" team works together on 1-2 construction problems. One student does it on the board while others guide. Team members discuss, correct errors, and explain steps to each other, Teacher moves round to guide and ask probing questions. Team Presentation one member from each team explains their solution to the class.

STAGE 2: Pair Goal: Reduce support, increase responsibility Pair Formation: Break the team into pairs. High plus low achiever pairing works best. Pair Task: Give a new but related construction problem. E.g. construct angle 30°. Peer Tutoring: Students work in twos. They take turns constructing and checking each other's work, they explain the steps to their partner: "First draw a line, then..."Teacher provides minimal guidance, only when pair is stuck. Random pairs present their construction and explain to the class.

STAGE 3: SOLO Goal: Independent mastery and assessment of Individual Task: Give each student a new construction problem to do alone. E.g. "Construct an equilateral triangle and bisect one angle". Independent Work: No talking. No help from peers. Students rely on what they learned in Team and Pair stages. Teacher collects and marks and use the data it for post test scores.

3 Results and Discussions

The results of this study are presented in Tables bellows according to research questions and null hypotheses.

Research Question One: What is the effect of Team-Pair-Solo instructional strategy on students' engagement scale during Construction lessons in Zaria Education Zone?

Table **1**

Mean and Standard Deviation on Students Engagement Scale when taught Construction Concepts Using Team-Pair-Solo Instructional Strategy and Conventional method

Methods	Type of Tests	N	Mean	St. Div.
Team Pair Solo	Pre-test	72	15.70	6.44
	Post-test	72	24.92	2.34
Conventional	Pre-test	60	13.83	6.23
	Post-test	60	14.45	4.92

Table 1 shows that, the pre-test and post-test mean and standard deviation of mean engagement ratings of students taught construction concept using Team-Pair-Solo Strategy are (N= 72, Mean = 15.70, Std. Div. = 6.44) and (N= 72, Mean = 24.92, Std. Div. = 2.34) the pre-test and post-test mean and standard deviation of students engagement ratings of students' taught construction concept using conventional method are (N= 60, Mean = 13.83, Std. Div. = 6.23) and (N= 60, Mean = 14.45, Std. Div. = 4.92) respectively.

Null Hypothesis One: There is no significant difference in the mean engagement scores of students taught Construction concepts using Team-Pair-Solo instructional strategy and those taught using the conventional method.

Table **2**

Result of ANCOVA Analysis on Students Engagement Scale of Experimental and Control Groups

Source	Type III Sum of Squares	df	Mean Square	F	p-value
Corrected Model	4929.490[a]	2	2464.745	182.657	<.001
Intercept	5678.871	1	5678.871	420.850	<.001
PRETEST	150.196	1	150.196	11.131	.001
METHODS	**4689.552**	**1**	**4689.552**	**347.534**	**.001**
Error	1619.257	129	13.494		
Total	50195.000	132			

Corrected Total	6548.748	131

Table 2 showed that, there is significance different between the means engagement ratings of students when exposed to TPS strategy and Conventional method. The value of $F_{(1,129)} = 347.534$ is obtained with associate exact probability value of 0.001. Since the associated probability value is less than alpha value of 0.05 level of significance. Therefore, for p-value observed is less then alpha value ($p < 0.05$), it means the difference is significant. Therefore, the null hypothesis one is hereby rejected.

Research Question Two: What is the effect of Team-Pair-Solo instructional strategy on students' performance in Construction concepts in Zaria Education Zone?

Table **3**

Mean and Standard Deviation on Students Performance Scores when Taught Construction Concept Using TPS Strategy and Conventional Method

Groups	**Test**	**N**	**Mean**	**St. Div.**
Experimental	Pre-test	72	9.64	2.26
	Post-test	72	17.19	3.46
Control	Pre-test	60	10.02	2.16
	Post-test	60	10.92	1.46

Table 3 shows that, the pre-test and post-test mean and standard deviation of mean performance scores of students taught construction concept using TPS strategy are (N= 72, Mean = 9.64, Std. Div. = 2.26) and (N= 72, Mean = 17.19, Std. Div. = 3.46), the pre-test and post-test mean and standard deviation of students performance scores taught construction concept using conventional method are (N= 60, Mean = 10.02, Std. Div. = 2.16) and (N= 60, Mean = 10.92, Std. Div. = 1.46) respectively.

Hypothesis Two: There is no significant difference in the mean performance scores of students taught construction concepts using Team-pair-solo instructional strategy and those taught using

conventional lecture method.

Table **4**

Result of ANCOVA Analysis on Students Mean Performance Scores in Construction when Exposed to TPS and Conventional Method

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	1179.368[a]	2	589.684	282.374	.000	.828
Intercept	1053.140	1	1053.140	504.303	.000	.812
PRETESTACH	1.179	1	1.179	.564	.454	.005
METHODS	**1175.881**	**1**	**1175.881**	**563.078**	**.000**	**.828**
Error	244.332	129	2.088			
Total	24776.000	132				
Corrected Total	1423.700	131				

Table 4 showed that, there is significance different between the means performance scores of students when taught construction concepts using TPS instructional strategy and Conventional method. The value of $F_{(1,129)} = 563.078$ is obtained with associate exact probability value of 0.000. Since the associated probability value is less than alpha value of 0.05 level of significance. Therefore, for p-value observed is less then alpha value ($p < 0.05$), it means the difference is significant. Therefore, the null hypothesis two is hereby rejected.

Research Question Three: What is the difference in engagement ratings of male and female students taught construction concepts using Team- Pair- Solo instructional strategy?

Table **5**

Mean and Standard Deviation on Engagement Ratings of Male and Female Students Taught Construction Concepts Using TPS Instructional Strategy

Gender	Type of Test	N	Mean	Std. Div
Male	Pre-test	42	15.83	1.82
	Post-test	42	17.12	1.77
Female	Pre-test	30	15.54	1.79
	Post-test	30	16.90	1.74

Table 5 shows the results of pre-test and post-test mean engagement ratings and standard deviation of male students' taught construction concepts using TPS Strategy are (N = 42, Mean = 15.83, Std. Div. = 1.82) and (N = 42, Mean = 17.12, Std. Div. = 1.77), while pre-test and post-test mean engagement ratings and standard deviation of female students' taught construction concepts using TPS Strategy are (N = 30, Mean= 15.54, Std. Div. = 1.79) and (N = 30, Mean = 16.90, Std. Div. = 1.74) respectively.

Hypothesis Three: There is no significant difference in the engagement ratings of male and female

students taught Construction concepts using Team-Pair-Solo instructional strategy.

Table **6**

Result of ANCOVA Analysis on Engagement Ratings of Male and Female Students Taught Construction Concepts using TPS Instructional Strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	31.565[a]	2	15.782	3.084	.053
Intercept	7696.183	1	7696.183	1503.952	<.001
PRETEST	31.546	1	31.546	6.165	.016
GENDER	**.812**	**1**	**.812**	**.159**	**.692**
Error	307.038	69	5.117		
Total	39464.000	72			
Corrected Total	338.603	71			

Table 6 showed that, there is no significance different on the means engagement ratings of male and female students taught construction concepts using TPS instructional Strategy. The value of $F_{(1,69)} = .159$ is obtained with associate exact probability value of 0.692. Since the associated probability value is greater than alpha value of 0.05 level of significance. Then, the p-value observed is greater than alpha value ($p > 0.05$) it means the difference is not significant. Therefore, the null hypothesis three is hereby not rejected.

Research Question Four: What is the difference in academic performance of male and female students taught Construction concepts using Team-Pair-Solo instructional strategy?

Table **7**

Mean and Standard Deviation on Performance Scores of Male and Female Students Taught Construction Concepts using Team-Pair-Solo Instructional Strategy

Gender	Type of Test	N	Mean	Std. Div
Male	Pre-test	42	15.69	6.09
	Post-test	42	24.94	2.35
Female	Pre-test	30	16.01	6.73
	Post-test	30	24.92	2.36

Table 7 shows the results of pre-test and post-test mean performance scores and standard deviation of male students' taught construction concepts using TPS instructional Strategy are (N = 42, Mean = 15.69, Std. Div. = 6.09) and (N = 42, Mean = 24.94, Std. Div. = 2.35), while pre-test and post-test mean performance scores and standard deviation of female students'

taught construction concepts using TPS Strategy are (N = 30, Mean= 16.02, Std. Div. = 6.73) and (N = 30, Mean = 24.92, Std. Div. = 2.36) respectively.

Null Hypothesis Four: There is no significant difference in the mean performance scores of male and female students taught construction concepts using TPS instructional Strategy.

Table **8**

Result of ANCOVA Analysis on Mean Performance Scores of Male and Female Students Taught Construction Concepts using TPS instructional Strategy

Source	Type III Sum of Squares	df	Mean Square	F	p-value	Partial Eta Squared
Corrected Model	1.357[a]	2	.679	.291	.748	.010
Intercept	940.720	1	940.720	403.899	.000	.873
PRETACHEX	1.019	1	1.019	.437	.511	.007
Gender	**.282**	**1**	**.282**	**.121**	**.729**	**.002**
Error	137.417	69	2.329			
Total	18674.000	72				
Corrected Total	138.774	71				

Table 8 showed that, there is no significance different on the means performance scores of male and female students taught construction concepts using TPS instructional Strategy. The value of $F_{(1,69)} = .121$ is obtained with associate exact probability value of .729. Since the associated probability value is greater than alpha value of 0.05 level of significance (P> 0.05). Then, the p-value observed is greater than alpha value it means the difference is not significant. Therefore, the null hypothesis four is hereby retained.

4 Discussions of Findings

The study showed that students taught with TPS had significantly higher engagement scores than those taught with lecture method. This suggests that TPS made students more active, participatory and interested in Construction lessons. This result is in agreement with Johnson & Johnson (2019) who noted that cooperative strategies increase students' on-task behaviour and motivation. It also supports Yusuf (2017) who found that TPS reduced students' passiveness and increased their involvement in Mathematics classes. During Team stage, students discussed and defended their ideas, while in Pair stage they tutored one another. This active involvement likely accounted for the higher engagement. The result of the study further revealed that students taught Construction concept using Team-Pair-Solo instructional strategy performed significantly better than those taught using conventional method. This implies that TPS provides students with opportunity for peer interaction, explanation and immediate feedback which enhanced their understanding of construction procedures. This finding agrees with Umar (2025) who stated that cooperative learning structures like TPS improve academic performance because students learn from one another. It also corroborates the findings of Adedoja (2018) and Ogunbiyi (2020) who reported that students taught Mathematics with TPS had higher post-test scores than those taught with lecture method. The reason for this may be that in TPS, weak students receive help from high achievers during Team and Pair stages before working independently in Solo stage. This is in line with Vygotsky's Social Constructivist Theory (1978) which emphasized learning through social interaction.

The result indicated no significant difference in the engagement level of male and female students taught with TPS. This means both male and female students were equally engaged when taught with TPS. This agrees with Eze (2019) who found that cooperative strategies promote equal participation of boys and girls in the classroom. The structured nature of TPS ensures that every student, regardless of gender, gets a chance to talk, listen and present during Team and Pair stages. The finding revealed no significant difference in the performance of male and female students taught Construction using TPS. This implies that TPS is gender friendly and benefits both male and female students equally. This finding supports Akinsola (2018) and Nwoke (2016) who reported that cooperative learning strategies bridge gender gaps in Mathematics performance. The reason may be that TPS gives equal opportunity for both sexes to contribute in Team and Pair stages irrespective of gender. This contradicts Aina (2015) who found males performed better, possibly due to differences in context and subject area.

5 Summary

This study investigated the impact of Team-Pair-Solo instructional strategy on students' engagement and performance in Construction concept in Zaria Education Zone, Kaduna State, Nigeria. The study adopted a quasi-experimental research design of pre-test, post-test, non-equivalent control group. The population comprised (7,870) SS2 students in public secondary schools in Zaria Education Zone. Purposive sampling and simple random sampling techniques was used to sample (132) SS2 students from 2 intact classes in 2 schools for the study. Two instruments were used for data collection: Construction Performance Test (CPT) and Construction Engagement Scale (CES). The instruments were validated by experts and reliability coefficients of 0.88 and 0.79 were obtained respectively using Kuder-Richardson 20 and Cronbach Alpha. The experimental group was taught using Team-Pair-Solo strategy while the control group was taught using conventional method for 6 weeks. Data collected were analysed using Mean, Standard Deviation, and ANCOVA for hypotheses testing at 0.05 level of significance. The major findings of the study revealed that, Students taught with TPS had significantly higher engagement scores than those taught with lecture method. Students taught Construction using Team-Pair-Solo instructional strategy performed significantly better than those taught using conventional lecture method. There was no significant difference in the engagement of male and female students taught with TPS. There was no significant difference in the performance of male and female students taught Construction using TPS.

6 Conclusion

Based on the findings of this study, it is concluded that Team-Pair-Solo instructional strategy is more effective than conventional lecture method in improving students' engagement and performance in Construction concept. The strategy promotes active participation, peer learning and gradual movement from guided practice to independent work. Furthermore, TPS was found to be gender neutral as it benefited both male and female students equally. Therefore, the use of TPS in teaching Construction concept in secondary schools in Zaria Education Zone is recommended.

7 Recommendations

Based on the findings of this study, the following recommendations are made:

1. Mathematics teachers in Zaria Education Zone and Nigeria at large should adopt Team-Pair-Solo instructional strategy in teaching Construction concept in order to improve students' engagement and performance.
2. The Kaduna State Ministry of Education and NTI should organize seminars and workshops to train Mathematics teachers on the effective implementation of TPS in the teaching of construction concepts in the classroom.
3. Textbook authors and curriculum developers should embed TPS strategy in teaching construction concepts in Mathematics textbooks for easy implementation.
4. School administrators should provide adequate instructional materials such as compass, ruler and protractor to enable effective use of TPS during Construction lessons.
5. Teachers should ensure heterogeneous grouping during TPS to allow gender, high, average and low achievers to learn construction concepts from one another.

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