ENHANCING HIGHER-ORDER THINKING SKILLS AND RETENTION OF MATHEMATICAL CONCEPTS USING THINK-PAIR-SHARE TEACHING STRATEGY

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Abstract
*Mathematics is a discipline intertwined with society, thatr is being used on daily lives, and thus, requires careful handling by the teachers in the school. The study examined how upper-basic students can be enhancedin higher-order thinking skills and retention rates with the use of think-pair-share instructional method in learning mathematical concepts. It employed a 2x2x2x2 non-equivalent intact classes research design, involving a population of 33,320 students from Basic 7, 8, and 9, and targeted 16,365 students in Basic 9. Respondents were selected through multistage sampling (*simple and purposive random sampling techniques). *The control and experimental groups were taught using different modules, and performance was evaluated using pre-test (PREMPT) and post-test (POSTMPT) instruments, with reliability coefficients of 0.75 and 0.81 respectively. Four research objectives were raised, transformed into hypotheses and tested using ANCOVA. The showed that the teaching strategy applied enhanced higher-order thinking skills and retention rates. The finding also showed that no gender difference was observed in the two groups. The study concluded that this approach can improve critical thinking and retention skills in mathematics if properly handled. It was recommended among others that students should be encouraged in the use of collaborative the chique in solving mathematics problems.*

Keywords: Higher-Order Thinking Skills, Mathematical Concepts, Retention, Teaching Strategy, Think-Pair-Share

Introduction

The term Education is an elusive word, hence, difficult to define and describe. Whatever definition or meaning given to it, depends on the situation and circumstances. Education is defined as the process that aims to develop analytical skills, fostering critical thinking for effective problem-solving (Adeyemi, 2012). In the same vein, education fosters critical thinking as a means of applying problem-solving skills, encouraging innovative approaches to complex issues (OECD, 2016). It is, therefore, the most potent weapon of development in any society. This is why the National Policy on Education, described education as an instrument par excellence for effecting national development (Federal Republic of Nigeria, 2004). In another development, the National Policy of Education (2014), education in

Nigeria aims in harvesting potentials and skills that are in an individual learner for self-fulfillmentand general development of the society. It also aims to explore the functional skills and competencies necessary for future self-reliance. As part of the goals of education in Nigeria, the National Policy on Education (2014) highlights the following goals of education among others:

a) provision of equal access to qualitative educational opportunities;
b) development of the necessary qualities and competencies mentally, physically, and socially, to enable the person to survive;
c) promote functional education for skill acquisition;
d) ability of the learners to make rational decisions;
e) the development of the practical knowledge and abilities required for independence.
f) give the child the chance to acquire the manipulative skills necessary to contribute to society efficiently;
g) inculcate in the learner the spirit of enquiry and creativity;
h) build a solid foundation for critical, scientific, and reflective thought;
i) Provide opportunities for the learner to develop life-manipulative skills that will enable him/her to function effectively in society; and
j) individuals capable of independent thinking.

All the Nigerian educational philosophies and goals, they are put together to enhance thinking and functional skills that can be of assistance in the nearer future engagement. To address Nigeria's fundamental educational goals, one of the subjects put in place is mathematics. It must be noted that mathematics is as old as human society and remains vital in our daily activities. It is a fundamental field of study, serving as the basis for other sciences and the backbone to other disciplines. Mathematics education involves concepts, principles, and their applications to everyday life (Odo, 2018). Specifically, at the basic level, mathematics aims at helping students to (a) understand and acquire basic mathematical concepts and computational skills; (b) develop creativity and the ability to think, communicate, and solve everyday life problems; and (c) enhance their lifelong learning abilities (TIMSS, 2015). Mathematics helps to provide learners with ample opportunities to acquire practical skills that enable them to navigate societal problems effectively.

Scholars such as Rittle-Johnson and Schneider (2015) emphasize the significance of conceptual understanding and procedural skills needed to learn mathematics. Due to its importance, the teaching and learning of mathematics requires careful guidance and instructions at all levels of education.

In order to accomplish these crucial educational objectives, a well-functioning human brain plays a vital role. The human brain is responsible for processing information and governing human behaviors, making it an indispensable cognitive organ for everyday reasoning. It's important to emphasize that the two hemispheres of the brain, depicted in Figure 1, actively interact and communicate with each other to fulfill their functions.

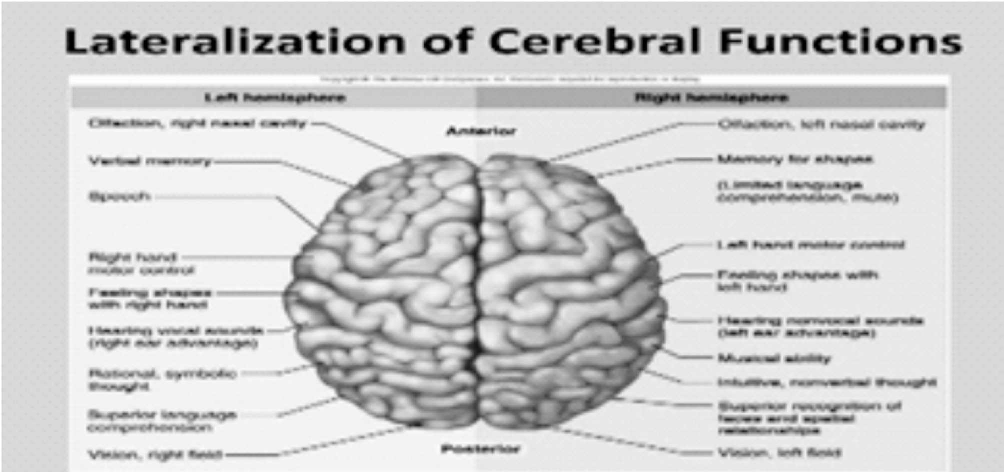

Figure 1: Lateralization of Cerebral Functions
Source:https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.slideserve.com%2Ftosca%2Fcentralnervoussystem&psig=AOvVaw0ySLVQS4yuf3LPdhPQSkqp&ust=1665644780374000&source=images&cd=vfe&ved=0CAoQjhxqFwoTCPimv8mQ2voCFQAAAAAdAAAAABAo

Cognitive neuroscience is a network within the human brain and spinal cord that influences various activities. It primarily explores abstract thinking and its connection to learning. The functions encompass speech, language, thinking, reading, problem-solving, information synthesis, and fostering creativity. The impact of cognitive neuroscience on student learning is significant (Prihantoro& Suyadi, 2021; RS Policy Statement, 2001; Chidozie et al., 2014).

The concept of a taxonomy of educational objectives was initially proposed by Bloom et al. (1956). It encompasses three domains: cognitive, affective, and psychomotor, while the cognitive domain is the focus of this study. This cognitive domain consists of six hierarchical levels used to evaluate a learner's cognitive ability. These levels represent intended learning outcomes that should be achieved by the end of a lesson, week, term, session, or academic program. It was first introduced by Bloom et al (1956) and later updated by Anderson & Krathwohl (2001). Six levels of cognitive domains are recognized as knowledge, comprehension, application, analysis, synthesis, and evaluation usingnouns to describe them. However, Anderson & Krathwohl (2001) described them hierarchically asforms of memory that function to produce collective remembering, understanding, applying, analyzing, evaluating, and creating (refer to Figure 2 for visualization).These forms of memory that are cognitive objectives can be grouped into lower order thinking and upper order thinking. The lower thinking has 3 subgroups namely, remembering, understanding, and applying while the upper domain also has 3 subgroups, analyzing, evaluating, and creating referred to as higher-order thinking skills (Gregory and Robinson, 2011), depicted in Figure 2.

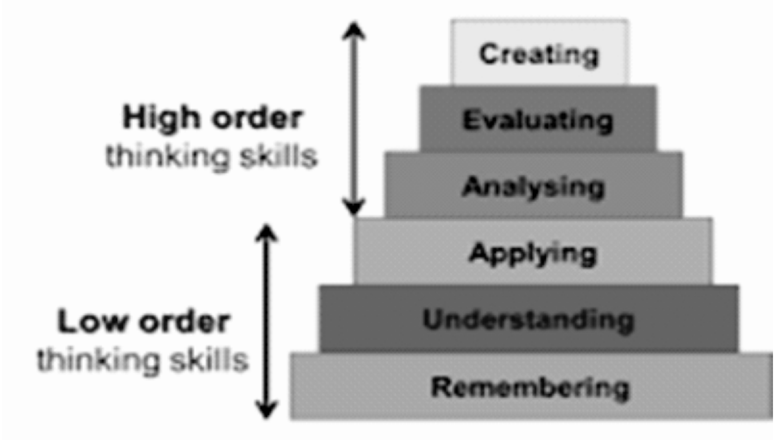

Figure 2: Lower and Higher-Order Thinking skills (Anderson & Krathwohl 2001)
Source:https://sites.google.com/site/supersophomores675/l

This study, therefore, hangs on higer-order thinking. The concept is a latent varible that combines cognitive science and psychometric models, hence there is no single agreed definition for it, and therefore,there are differences in how the concept is defined and what makes up each of its components.Bloom and his team refer to higher-order thinking as the capacity of an individual learner to have critical reflection and the power to solve problems in complex situations. It also involves the ability of the learners to analyze, synthesize, and evaluate information beyond basic comprehension.

Higher-order thinking involves connecting prior knowledge with new situations, surpassing mere memorization. These skills promote critical and creative thinking to solve problems, as described by Saraswati &Agustika (2020). Furthermore, Istikhomah et al. (2022) note that individuals with advanced thinking abilities must analyze, connect, deconstruct, and comprehend elements of concepts to generate solutions or original ideas. Higher-order thinking skills encompass evaluation and innovation, extending beyond simple knowledge recall and understanding, as discussed by Chinedu et al. (2015). These domains were broadly described as intellectual abilities that allow learners to provide solutions to learning activities without rote memorization and make the right decisions in solving learning problems.

Extensive research has focused on higher-order thinking abilities. One such is (Zulfiani, et al., 2017).The researchers examined how guided and unguided inquiry-based learning has influence on students' higher-order thinking skills. The findings showed that guided and free inquiry learning strategies heightened students' higher-order thinking abilities. Notably, there were no disputes in higher-order thinking skills based on students' gender.

Rahayuningsih and Jayanti (2019) conducted a study on mathematical problem-solving in group theory and gender. The researchers examined the high-order thinking abilities of students and found that male students had a higher ability in analysis (66.67%) compared to females (62.5%), while females performed better in evaluation (43.75%) compared to males (33.33%). However, both genders showed equal performance in the creation stage (0% for both). Overall, males outperformed females in analysis, while females excelled in evaluation, and both genders performed similarly in creativity.

Takko et al. (2020) conducted a study to examine the impact of cooperative learning student teams on the development of higher-order thinking skills among home science students. The results showed that the students actively engaged in learning. After the intervention, their post-test responses demonstrated improved accuracy in answering questions that required higher-order thinking skills, along with concise reasoning. This study suggests that the Home Science Student Teams-Achievement Divisions Module can serve as a valuable resource for teachers seeking toemploy strategies that can enhance higher-order thinking when teaching.

Higher-order thinking skills lack a universally accepted definition. According to Kareem (2022), there may be differences in terminology when it comes to defining their constituent parts. The findings showed that inquiry-based learning significantly enhanced students' capacity for higher-order thinking. Moreover, the experimental group displayed higher mean scores in application skills compared to the control group, highlighting the effectiveness of this learning approach. Jamaluddin et al. (2020) conducted a study examining the growth of higher-order thinking skills in home science students through the implementation of cooperative learning student teams using the STAD Module. The findings indicated that the Home Science STAD Module serves as an effective instructional resource for educators aiming to integrate higher-order thinking skills into their lesson plans.

Retention is another important variable in this study.It is defined as the ability to store and recall information, tasks, or knowledge acquired by an individual. It encompasses the capacity to remember and apply learned knowledge and skills over time. Retention is crucial for learners to retain and recall information, concepts, and skills acquired during the learning process. It also involves the ability to apply learned concepts in practical situations and transfer knowledge to new contexts. Ultimately, retention reflects the effectiveness of the learning process in facilitating long-term understanding and skill development, serving as a measure of the durability and persistence of learning outcomes. The researchers hypothesized that anything that enhances teaching and learning should improve retention, as it plays a vital role in the successful acquisition of knowledge in education.

Numerous research studies have explored retention, including the work of Owodunni and Ogundola (2013). The researchers examined the differences between genders in the academic performance and retention of Nigerian students who were exposed to electronic commerce through reflective inquiry. The findings indicated that boys taught using the reflective inquiry instructional technique, achieved higher mean scores than girls. However, when it came to the retention test, girls outperformed boys with higher mean scores.

Ajai and Imoko (2015) conducted a study using Problem-Based Learning to assess gender differences in mathematics achievement and retention. The results indicated that male and female students taught algebra with PBL showed no significant differences in achievement and retention scores. This suggests that both genders are capable of excelling and collaborating in mathematics, indicating that performance is determined by orientation rather than gender. Adeniran et al (2018) investigated the impact of the concept mapping strategy on students' retention in Basic Science. The study included two research questions and two hypotheses. The results demonstrated that students taught Basic Science using the concept mapping strategy showed significant improvement, with a mean retention score of 52.72 compared to 33.21 for those taught using the conventional method. The data also showed a slight advantage for females, as they gained slightly higher retention scores compared to males (-1.58 mean difference). Tukura et al. (2020) investigated how e-learning affected basic science students' performance and retention in Minna, Niger State.

The findings indicated that Students' retention and performance were positively impacted by the usage of e-learning in Basic Science.Additionally, a study conducted by Valderrama and Oligo (2021) investigated the retention of mathematics learning over consecutive weeks, specifically focusing on the impact of motivated forgetting. The results indicated the following: 1) the amount of retained learning among students followed a negative exponential curve, diminishing over time; 2) the level of retained learning was relatively equal to the initial amount of learning up to the second week; 3) after the third week, the amount of retained learning became significantly lower than the initial amount.4) concepts at the knowledge level were more likely to be remembered, while concepts at the analysis level were prone to motivated forgetting.

In a different study, Okpe et al. (2022) looked at gender variations in secondary school pupils' retention and achievement in mathematics in Nsukka Education Zone, Enugu. The findings revealed that male students outperformed their female counterparts in mathematics achievement. Gender was identified as a significant factor, as male students also demonstrated higher retention abilities in mathematics, which corresponded to their superior achievement compared to female senior secondary school students.

Onyeka et al (2023) conducted a study in Rivers State to analyze the impact of the demonstration teaching method on students' academic retention in Mathematics. The results showed that students taught with the demonstration method retained more information compared to those taught with the deductive method. Furthermore, there was no discernible difference in retention between male and female students who received instruction using the demonstration technique. In a separate study, Egara&Mosimege (2023) investigated the retention of algebra concepts among learners using a computer simulation program. The findings indicated that students taught algebra with computer simulation achieved significantly higher average retention scores compared to those taught through traditional methods. Moreover, a gender difference was observed in the retention scores of students who learned algebra concepts using computer simulation.

The treatment variable in this study is the teaching method known as Think-Pair-Share.It is a cooperative learning approach that stimulates continuous thinking and the generation of individual ideas on a specific topic. These thoughts are subsequently shared and discussed with other group members. Think-Pair-Share involves three stages: individual contemplation (think), collaboration with a partner (pair), and sharing of ideas with the entire class (share). This strategy enhances group interaction and encourages higher-order thinking (Ogunniyi, 2018; Richards and Rodgers, 2001).

Numerous scholars have examined the think-pair-share approach on various factors. For example, Ofoegbu and Akubuilo (2016) investigated the impact of this cooperative learning technique on the critical thinking abilities of Biology students in secondary schools. According to their findings, students' critical thinking abilities and comprehension of difficult concepts were improved by the think-pair-share strategy. Similarly, Adeyemo and Adeyemo (2019) researched the implementation of the think-pair-share method in teaching mathematics to high school students in Oyo State, Nigeria. They observed that think-pair-share facilitated student engagement, motivation, and the development of a collaborative learning environment.

Agbede and Ba'aba (2019) conducted a study in northeastern Nigeria to examine the effects of Jigsaw and think-pair-share approaches on academic achievement in accounting among colleges of education. The findings indicated that both Students' academic performance in accounting concepts at college of education was considerably enhanced by the think-pair-share and Jigsaw techniques in northeastern Nigeria.Yusuf, et al. (2018) looked into how well Bayelsa, Nigerian students performed in civic education when using the think-pair-share teaching method. Their study revealed that Students that were taught civics using the Think-Pair-Share method did better than those in the control group.Gender did not have a significant effect on civic education achievement among secondary school students.

Alabi and Sanni (2021) examined the effects of the think-pair-share instructional technique on learning outcomes in secondary school mathematics. The results of the pretest and posttest were important, and they showed no statistically significant interactions between gender and ability level, group and ability, or gender and group. The think-pair-share technique positively impacted students' performance in senior secondary school mathematics.Abiodun and colleagues (2022) examined how the think-pair-share method affected students' performance in senior secondary school mathematics. Their study demonstrated that the think-pair-share technique had a significant impact on students' performance in mathematics. Furthermore, no main effect of gender on students' achievement in mathematics was found.

The study was motivated by a report from ESSPIN (2011) indicating that a significant number of Nigerian primary and secondary school graduates lacked basic reading and mathematical skills. This finding was identified as a major factor contributing to poor academic performance in mathematics. Additionally, Omenka (2010) attributed subpar performance to teachers' insufficient utilization of effective teaching methods. Consequently, this study aims to investigate the potential benefits of implementing the thinking-pair-share teaching technique to enhance higher-order thinking skills and retention of mathematical concepts, which have not been extensively studied in previous research conducted in Nigeria..

Research Objectives

1. enhancement of higher-order thinking skills using think-pair-share to teach mathematical concepts among upper-basic students.
2. enhancement of higher-order thinking skills using think-pair-share and students' gender as intervening variable
3. enhancement of retention capability of mathematical concepts using think-pair-share.
4. improve retention capacity by utilizing think-pair-share and the gender of the students as a variable

Research Hypotheses

In the course of this study, the following null hypotheses were postulated and tested:

H_{O1}: Think-pair-share teaching strategy has no significant effect in enhancing higher-order thinking skills in the teaching and learning of mathematical concepts among upper-basic students.

H_{O2}: Using the think-pair-share teaching technique, the gender of the students has no discernible impact on their ability to increase higher-order thinking skills.

H_{o3}: Think-pair-share teaching strategy has no significant effect in enhancing retention capability of mathematical concepts among upper-basic students.

H_{o4}: Students' gender as an intervening variable has no significant effect on retention capability when taught using the think-pair-share teaching strategy.

Method

This section dealt with the methods, techniques, or procedures used in conducting this study. The researcher employed a 2 X 2 X 2 X 2 quasi-experimental research design involving non-equivalent intact classes. The specific design is illustrated in Table 1.

Table 1: A 2 X 2 X 2 X 2 Quasi-Experimental Research Design

Groups	Baseline Measurement	Independent Variable	Mediating Variable	Follow-up Measurement Dependent Variables	
	Pretest	Treatment (think-pair-share)	Gender	Posttest 1	Posttest 2 (Retention)
Control	O_1	…	Male Female	O_2	O_3
. . .	. .	. . . . .	. . . .	. . . . . .	. .
Experimental	O_1	X	Male Female	O_2	O_3

This section dealt with the methods, techniques, or procedures that were employed in carrying out this study. This researcher adopted a 2 X 2 X 2 X 2 quasi-experimental r The study included a population of 33,320 upper-basic students in schools located in the Ilorin metropolis, specifically in basic 7, 8, and 9. The target population for this research comprised 16,365 students in basic 9 within the city (Kwara State Universal Basic Education Commission, 2023). Basic 9 was chosen due to the significant number of years the students had spent in the school environment and because they were in the final stage of basic education. It was believed that the students were adequately prepared for the study.

A multi-stage sampling procedure was employed in this study. The Ilorin metropolis comprised 105 upper-basic schools. In the first stage, two schools were sampled: one designated as the control group and the other as the experimental group, using a simple random sampling technique. It is worth noting that a purposive random sampling technique was utilized to select two co-educational schools, allowing for consideration of students' gender. The control group consisted of 46 students while the experimental group comprised 51 students.

Two categories of instruments were utilized. The first category consisted of two modules prepared and used as lesson plans in the control group and the experimental group. The lessons centred around four topics such as numbers and numeration, algebraic processes, geometry and measurement, and statistics. The second category encompassed the mathematics performance test, which comprised two components: the Pretest Mathematics Performance Test (PREMPT) and the Posttest Mathematics Performance Test (POSTMPT). All of the instruments were designed by the researcher.

During the construction of a mathematics performance test, the researcher utilized the revised Bloom's taxonomy of educational objectives. This taxonomy consists of two dimensions: knowledge processing skills and cognitive processing skills. The knowledge domain, which encompasses the topics taught and assessed, comprises four levels: number and numeration, algebraic processes, geometry and measurement, and statistics. The cognitive process domain, consists of three levels: analysis, evaluation and creativity (refer to Table 2).

Table 2: Table of Specification for Mathematics Test Items

	Themes	Cognitive Process Skills			
		Analysis 40%	Evaluation 30%	Creativity 30%	Total 100%
Cognitive Process Skills	Numbers& Numeration	6	5	5	16 (32.00%)
	Algebraic Processes	5	3	3	11 (22.00%)
	Geometry & Menstruation	4	3	3	10 (20.00(%)
	Statistics	5	4	4	13 (26.00%)
	Ground Total	20 Items (40%)	15 Items (30%)	15 Items (30%)	50 Items (100.0%)

Table 2 shows that out of the 30 test items, 16 (32.00%) were prepared for number and numeration. These items were distributed across analysis, evaluation, and creativity in proportions of 40%, 30%, and 30%, respectively. For algebraic processes, 11 (22.0%) of the test items covered analysis, evaluation, and creativity, with the same proportions as before. In the case of geometry and menstruation, 10 (20.00%) test items focused on analysis, evaluation, and creativity, again with proportions of 40%, 30%, and 30%. Additionally, statistics and probability had 13 (26.00%) test items dedicated to analysis, evaluation, and creativity, with the same proportions as the other categories. Each mathematics performance test item included four options: A, B, C, and D.

The instruments underwent psychometric analysis, including assessments of content validity and split-half reliability. Content validity was conducted on the five instruments using the item-level content validity scale and scale content validity. These assessments were administered to three lecturers from the Mathematics Education Unit at the Department of Science Education, University of Ilorin, Ilorin, Nigeria, as well as two experienced mathematics teachers from upper-basic schools.

The mathematics performance tests were administered once to basic 9 students who were not part of the actual study. Afterwards, split-half reliability was applied to assess the internal consistency of the test items. The split-half reliability estimate was also calculated through two steps. The first step involved item analysis, which focused primarily on item-level information. This analysis aimed to determine the desired quality of the test, ensuring high reliability in mathematics performance tests (MPTs). It was carried out in two parts: (a) computation of item difficulty and item discrimination using WinGen 3 Window software, and (b) utilization of Kuder-Richardson's KR20, a method for assessing the internal consistency of dichotomously scored items. The reliability values obtained for the mathematics performance tests were PREMPT (0.75) and POSTMPT (0.81), indicating that the instruments used for data collection in this study were sufficiently reliable.The intervention was completed within six weeks. During the first week, researcher assistants were trained, and pretests were administered to the three groups (two experimental and one control group) using PREMPT. Modules for the second, third, fourth, and fifth weeks were designed following the think-pair-share instructional strategy to improve higher-order thinking and retention.

Think-pair-share was the teaching style used with the experimental group; the control group was taught using the conventional method. In implementing a think-pair-share instructional strategy, three stages were involved. In the first stage, students engaged in individual thinking, prompted by a question presented during the lesson. They were given a few minutes to contemplate their response to the question silently. During this stage, students reflected deeply on the questions and jotted down their thoughts and answers. The second stage entailed students paired up with another student in their group and discussing how the question could be computed concerning the question. The teacher instructed the students to form pairs and encouraged them to exchange ideas and arrive at an answer together. In the third stage, students shared their thoughts and answers with the other members of their group before they shared them with the teacher and other colleagues in the class. All two groups received instructions on the same topics (Number and Numeration, Algebraic Processes, Geometry & Menstruation, and Statistics) for four weeks. The sixth week was reserved for conducting post tests across the groups. Finally, the teacher facilitated and corrected the students in the computation of answers

RESULTS

The scores obtained from the pretest and post test were collected, focusing on higher-order thinking skills and retention, in both the control and experimental groups. Gender was considered as a mediating variable. The collected set of scores was analyzed using inferential statistics (Analysis of Covariance) with the help of SPSS 25.0 IBM version. The results are presented in the preceding tables.

Hypotheses Testing

H_{01}: *Think-pair-share teaching strategy has no significant effect in enhancing higher-order thinking skills in the teaching and learning of mathematical concepts among upper-basic students.*

Table 3: Performance of Students in Higher-Order Thinking Skills that were Exposed to Think-Pair-sh#are.

Source of Variance	Type III Sum of Squares	df	Mean Square	F	Sig.	Decision
Corrected Model	13647.301[a]	2	6823.650	83.469	.000	
Intercept	3438.847	1	3438.847	42.065	.000	
Pretest	7796.675	1	7796.675	95.371	.000	
Groups	2747.841	1	2747.841	33.612	.000	S
Error	4986.808	61	81.751			
Total	170247.000	64				
Corrected Total	18634.109	63				

R Squared = .732 (Adjusted R Squared = .724)
P < 0.05

Table 3 reveals the results of a one-way ANCOVA comparing the higher-order thinking skills of students in the traditional learning mode and those exposed to think-pair-share among upper-basic students in Ilorin. The output indicates that the calculated significant value (0.000) is less than the chosen 0.05 level of significance. Hence, the null hypothesis is rejected. Thus, there is a significant positive effect of treatment and control on the performance of students in higher-order thinking skills among upper-basic students in Ilorin ($F_{(2, 64)} = 33.612$; $p < 0.05$). This is in favour of students exposed to think-pair-share, with a mean score of 60.23 greater than the traditional strategy mean score of 40.76.

H_{O2}: Students' gender as an intervening variable has no significant effect on the enhancement of higher-order thinking skills when taught using a think-pair-share teaching strategy.

Table 4: Effect of Gender on the Performance of Students in Higher-Order Thinking Skills that were Exposed to Think-pair-Share

Source of Variance	Type III Sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected Model	10923.291[a]	2	5461.645	43.207	.000	
Intercept	1881.043	1	1881.043	14.881	.000	
Pretest	10907.249	1	10907.249	86.287	.000	
Gender	23.831	1	23.831	.189	.666	NS
Error	7710.818	61	126.407			
Total	170247.000	64				
Corrected Total	18634.109	63				

a. R Squared = .586 (Adjusted R Squared = .573)
P > 0.05

Table 4 shows the results of the effect of gender on the differences in performance between students using the traditional learning mode and those exposed to think-pair-share in higher-order thinking skills (HOTS) among upper-basic students. The output indicates that the calculated significant value (0.720) is greater than the chosen 0.05 level of significance. Hence, null hypothesis 2 is not rejected. Thus, it suggests that gender has no discernible impact on pupils' performance in higher-order thinking skills that are exposed to treatment and control among upper-basic students in Ilorin ($F_{(2,64)} = 23.831; p > 0.05$).

Ha_{O3}: Think-pair-share teaching strategy has no significant effect in enhancing retention capability of mathematical concepts among upper-basic students.

Table 5: Difference in the Performance of Students in Retention that were Exposed to Think-Pair-Share

Source of Variance	Type III Sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected Model	29856.730[a]	2	14928.365	191.182	.000	
Intercept	17.336	1	17.336	.222	.639	
Pretest	18237.394	1	18237.394	233.559	.000	
Groups	1444.858	1	1444.858	18.504	.000	S
Error	7339.951	94	78.085			
Total	191199.000	97				
Corrected Total	37196.680	96				

a. R Squared = .803 (Adjusted R Squared = .798)
P < 0.05

Table 5 reveals the results of a one-way ANCOVA showing the effectiveness of learners who participate in think-pair-share and those in the traditional learning mode on higher-order thinking skills (HOTS) among upper-basic students. The output indicates that the calculated significant value (0.000) is less than the chosen 0.05 level of significance. Hence, the null hypothesis is rejected. Thus, there is a significant positive effect of treatment and control on the retention capability of mathematical concepts among upper elementary students ($F_{(2,64)} = 33.612; p < 0.05$). This is in favour of students exposed to think-pair-share, with a mean score of 60.23 greater than the traditional strategy's 40.76.

H_{O4}: Students' gender as an intervening variable has no significant effect on retention capability when taught using a think-pair-share teaching strategy.

Table 6: Effect of Gender in the Performance of Students in Retention that were Exposed to Think-Pair-Share

Source of Variance	Type III Sum of Squares	df	Mean Square	F	Sig.	Decision
Corrected Model	28418.196[a]	2	14209.098	152.151	.000	
Intercept	174.078	1	174.078	1.864	.175	
Pretest	28418.156	1	28418.156	304.302	.000	
Gender	6.325	1	6.325	.068	.795	NS
Error	8778.484	94	93.388			
Total	191199.000	97				
Corrected Total	37196.680	96				

a. R Squared = .764 (Adjusted R Squared = .759)

P > 0.05

Table 6 indicates the results of the effect of gender on It follows that there is no discernible effect between gender and students' performance in traditional learning mode among upper basic students. The output indicates that the calculated significant value (0.795) is greater than the chosen 0.05 level of significance. Hence, null hypothesis 4 is not rejected. It, therefore, states that there is no significant effect of gender in the retention capability of mathematical concepts among upper-basic students who are exposed to treatment and the control group ($F_{(2,67)} = 6.325; p > 0.05$).

Discussion of Findings

The first finding indicates that the performance of upper-basic students in Ilorin significantly improved in higher-order thinking skills when exposed to the think-pair-share method. This improvement can be attributed to the think-pair-share instructional strategy, which encourages the active participation of students in the learning process. Because of the way it is taught, students can take responsibility for their education. leading to better comprehension and retention of information. This outcome aligns with previous studies by Zulfiani et al. (2017) and Abdurrahman et al. (2021), which found positive effects on students' higher-order thinking skills through inquiry-based and guided inquiry learning models. Similarly, it is consistent with the findings of Takko et al. (2020) and Jamaluddin et al. (2020), who demonstrated the effectiveness of cooperative learning in enhancing higher-order thinking skills among students.

Furthermore, the study revealed that gender had no significant impact on the performance of students in higher-order thinking skills when they were exposed to the think-pair-share approach. This finding suggests that cognitive abilities, which are typically unrelated to gender, may be responsible for these results. Cognitive abilities are often influenced by a complex interplay of various factors, such as genetics, individual experiences, socio-cultural environment, and educational opportunities. These factors can have a greater influence on an individual's cognitive abilities than their gender. By employing the think-pair-share teaching method, equal opportunities were provided for both male and female students to enhance their higher-order thinking skills. This finding contradicts the findings of Rahayuningsih& Jayanti (2019), who observed differences in certain aspects of high-order thinking skills between male and female students.

Furthermore, the study also revealed a positive effect of think-pair-share and traditional teaching methods on the retention of mathematical concepts among upper-basic students. This finding could be attributed to the metacognitive skills possessed by individuals. Consequently, the think-pair-share instructional strategyenables the development and evaluation of students' own understanding of the concept being studied. The present finding aligns with thr finding of Adeniran et al. (2018) and Tukura et al. (2020), which demonstrated the effectiveness of concept mapping and e-learning in improving student retention. Similarly, studies by Ofoegbu and Akubuilo (2016), Adeyemo & Adeyemo (2019), and Yusuf et al. (2018) indicated the positive impact of the think-pair-share strategy on critical thinking skills, understanding of complex concepts, and achievement in various subjects.

Finally, the findings also show that gender did not significantly influence the retention capability of mathematical concepts among upper elementary students exposed to think-pair-share and traditional teaching methods. This finding can be attributed to the provision of equal educational opportunities and resources to students regardless of gender during the intervention. Both male and female students had access to the same quality of teaching, textbooks, study materials, and facilities. Some other possible factors that could influence students' retention capability include learning styles, motivation, prior knowledge, and study habits. These factors vary greatly from one student to another, irrespective of their gender. Therefore, gender alone cannot be considered a significant factor in determining retention capability. The equal participation and absence of gender-biased content ensured that both male and female students had an equal opportunity to effectively retain information.

The present finding aligns with Ajai &Imoko's (2015) research, which discovered no appreciable gender disparities in math proficiency and retention. However, it contradicts the results of Okpe et al. (2022), who identified gender differences in mathematics achievement and retention among secondary school students.The last finding state that there was a significant difference in the student's performance that were exposed to treatment in the experimental group only immediately after treatment (post-test 1) and three weeks later (post-test 2)

Conclusion

The study concluded that the implementation of the think-pair-share teaching strategy can yield numerous beneficial effects on the higher-order thinking skills and retention capability of upper-basic students in mathematical concepts. It was observed that when the think-pair-share instructional strategy is appropriately utilized in teaching, it fosters active student engagement, collaboration, and equal participation in effective learning of mathematical concepts. This, in turnenhances students' higher-order thinking skills and their ability to retain what they were taught the learned material.

Recommendations

The following recommendations are made:

1. The advice to teachers of mathematics is that they should encourage their learners to share thoughts, knowledge, and skills with other colleagues concerning areas of difficulty in mathematics. This may likely help their classmates study together and resolve common issues.
2. Think-pair-share should be incorporated into the curriculum reviews for upper-basic levels due to its positive impact on critical thinking and retention and being use when teaching ,mathematical concepts.
3. To effectively utilize the think-pair-share teaching strategy, teachers need to receive appropriate training and professional development. This ensures that educators comprehend the instructional strategy, recognize its benefits, and understand how to facilitate productive classroom interactions among students.
4. Conducting similar research in diverse educational settings and across different academic levels would be advantageous. This approach would provide a broader understanding of the effectiveness of the think-pair-share instructional strategy, its impact on student academic performance, and its integration into daily classroom activities.
5. Schools can also invest in suitable teaching resources, such as seating arrangements that facilitate discussions and materials that encourage active student engagement.

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