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EDITORIAL

Journal of Science Education and Research (JSER) is a peer-reviewed published Bimonthly. It aimed at advancing knowledge and professionalism in all aspects of educational research, including but not limited to innovations in science education, educational technology, guidance and counselling psychology, childhood studies and early years, curriculum studies, evaluation, vocational training, planning, policy, pedagogy, human kinetics, health education and so on. JSER publish different types of research outputs including monographs, field articles, brief notes, comments on published articles and book reviews.

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Prof. Patrick C. Igbojinwaekwu
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EFFECT OF TECHNOLOGY-ENHANCED INSTRUCTIONAL STRATEGY ON STUDENTS' CONCEPTUAL UNDERSTANDING OF PYTHAGORAS' THEOREM AT JUNIOR SECONDARY SCHOOLS IN KANO STATE NIGERIA

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Abstract

This study looked at how technology-enhanced instructional strategy can assist students' to understand Pythagoras theorem. The study area is Bichi, Kano State. Quasi-experimental research of pretest-posttest research design was used. Two research questions and two null hypotheses were developed for the study. The study population includes 1,986 students of public Junior Secondary School in Bichi local government area, Kano State. The ample size includes 62 students. Conceptual Understanding Test (CUT) was an instrument used for data collection. Cronbact Alpha was used to obtain the reliability coefficient of 0.88. Mean and standard deviations were used to answer research questions. Analysis of covariance (ANCOVA) was used to test the null hypotheses at 0.05 level of significant. Findings reviewed that, a significant difference was found in the mean achievement scores of students taught Pythagoras theorem with technology-enhanced instructions and those taught with traditional methods; a significant difference was not found in the mean achievement scores of male and female students when taught Pythagoras theorem using technology-enhanced instructions and traditional methods. The study recommends that, technology-enhanced instructional strategy should be applied by teachers in teaching Pythagoras theorem at all level; professional bodies such as Mathematical Association of Nigeria (MAN), Science Teachers Association of Nigeria (STAN) should organize seminars and workshops on the use of technology-enhanced instructional strategy at secondary schools. The study concludes that, technology-enhanced instructional strategy should be encourage and applied in teaching Pythagoras theorem and mathematics.

Keywords: Technology-enhanced Instructional Strategy, Achievement.

Introduction

Mathematics is a fundamental subject that plays a crucial role in our daily lives because of its daily application. As noted by the National Council of Teachers of Mathematics (2014) mathematics is a powerful tool for solving problems and understanding the world around us through quantitative and critical reasoning skills. Pythagoras theorem is one of the most essential theorems in mathematics, science and engineering because of its application features. The Pythagoras theorem, which states that "in a right-angled triangle, the square of the hypotenuse side is equal to the sum of squares of the other two sides", was found to be the fundamental concept in mathematics with numerous applications in science and real-world problems (Khan & Tahir 2018). Research has shown that students who have strong understanding of Pythagoras theorem are better equipped to solve problems in mathematics, science and other subjects. Ali and Khan (2020) note that student who received instruction on the application of Pythagoras theorem demonstrated significant improvements in their problem-solving skills. This theorem can improve students' conceptual understanding in mathematics because it has fundamental skills of solving problems that are related to real-life application.

Some findings show that, students often experience difficulties in understanding and applying Pythagoras theorem. Ozdilek (2019) observes some problem associated with students' difficulties in understanding and applying Pythagoras' theorem as; poor diagrammatic interpretation, poor conceptual understanding, procedural fluency and instructional methods. Traditional instructional methods (TIM), which usually depends on lectures, textbook-based instruction, no students' contributions and teacher-centered approach, may not be of benefits in promoting students' understanding of Pythagoras theorem for problem solving. The application of technology-enhanced instructional strategies (TEIS) has the potential to improve students' learning outcomes, but its effect on students' understanding of Pythagoras theorem at the Junior Secondary School (JSS) level is not well understood. There is every need to investigate the effect of TEIS on students' conceptual understanding and application of Pythagoras theorem.

With the aid of TEIS, students can engage with interactive and immersive learning experiences that can promote concept application. It could transform the way students learn and understand complex concepts, including Pythagoras theorem. National Council of Teachers of Mathematics (2014) informs that technology can facilitate deeper understanding and improve student learning outcomes in mathematics. So

technology-enhanced instructional strategy could motivates students to achieve better in mathematics and other fields.

Technology-Enhanced Instructional Strategies refer to the use of technology and internet facilities to support and impact knowledge and skills to the learner. It includes the use of interactive, multimedia and web-based services to support teaching and learning so as to improve student learning outcomes. According to Koh (2013) TEIS, such as simulations, games, and multimedia resources, can assist students for applied skills, motivation, positive attitude and improve learning outcomes in mathematics. The use of TEIS could reduce cognitive load and improve students' ability to apply mathematical concepts, including the Pythagoras theorem. By exploring the potential of TEIS to improve student learning outcomes, the study seeks to contribute to the growing body of research on the effective integration of technology in mathematics education. TEIS used are aligned with the curriculum and learning objectives because teachers are familiar with technology-enhanced instructional strategies and students also have access to computers and mobile devices with internet connectivity.

Mathematical Literacy refers to the ability to use mathematical concepts and skills to solve problems and make informed decisions in everyday life (Organization for Economic Co-operation and Development, 2013). In the context of mathematics and the Pythagoras theorem, Mathematical Literacy involves being able to apply the concept of the Pythagoras theorem to solve problems and make decisions in a variety of contexts. The application of the Pythagoras theorem has been shown to improve students' critical thinking and analytical skills. The use of the Pythagoras theorem in real-world problems can help students develop critical thinking and analytical skills (Ainsworth & Habgood 2020). According to Meyer (2012) mathematics is not just about solving problems, it's includes understanding the world around us so, Pythagoras theorem is one of the fundamental theory that can assist conceptual understanding of mathematics and its daily life application.

The integration of TEIS may transform the way students learn and understand complex mathematical concepts, including the Pythagoras theorem. According to Koh (2013) TEIS can improve student engagement, motivation, and learning outcomes in mathematics. Khan and Tahir (2018) observed that technology-enhanced instruction can improve students' conceptual understanding of mathematical concepts, including the Pythagoras theorem. The use of TEIS can lead to significant improvements in students' understanding of the Pythagoras theorem (Ali & Khan, 2020). Research has

identified various types of technology-enhanced instructional strategies that can be effective in improving students' conceptual understanding of the Pythagoras theorem. These include: Simulations (Koh, 2013), Games (Ainsworth & Habgood, 2020), Multimedia resources (Khan & Tahir 2018) and Online learning platforms (Ali & Khan, 2020).

Despite the potential benefits of TEIS, research has also identified several challenges and limitations. These include: Technical issues (Yusuf, 2019), Limited access to technology (Ali & Khan, 2020) and Teacher training and support (Khan & Tahir 2018). This literature supports the fact that TEIS can be effective in improving students' conceptual understanding of the Pythagoras theorem and mathematics at JSS.

The Cognitive Load Theory (CLT) posits that the too much cognitive load imposed on learners can affects their ability to process and retain information (Sweller, 1988). In the context of mathematics and the Pythagoras theorem, CLT suggests that learners who are presented with complex mathematical concepts, such as the Pythagoras theorem, may experience high cognitive load, leading to decreased understanding and retention. That, technology-enhanced instruction can reduce heavy cognitive load and assist students to improve academically and apply mathematical concepts effectively (Yusuf, 2019).

Technology-enhanced instructions can assist the learner to develop their own understanding skills through class activities. The Constructivist Theory (CT) according to Piaget, (1963) posits that learners construct their own knowledge and understanding through active engagement with the learning material. In the context of mathematics and the Pythagoras theorem, CT suggests that learners should be actively engaged in exploring and discovering the concept of the Pythagoras theorem, rather than simply being presented with the formula.

The Social Constructivist Theory (SCT) posits that learners construct their own knowledge and understanding through social interactions and collaborations (Vygotsky, 1978). In the context of mathematics and the Pythagoras theorem, (SCT) suggests that learners should be encouraged to work in groups to explore and discover the concept of the Pythagoras theorem. Therefore, TEL can be used to provide interactive and engaging learning experiences, such as simulations and games, to help learners understand and apply the concept of the Pythagoras theorem.

Statement of the Problem

Pythagoras theorems being an essential concept in the study of mathematics, many students especially at JSS level are not finding it easy to understand and apply it. A research conducted by Csaba and Hussein (2023), one of the findings report that most students find it difficult in understand and applying Pythagoras theorem in solving mathematical problems at school or at home. These give rise to poor results from students in mathematics and other fields. The 'oral teacher and board-centered teaching method' normally encourages memorization of concepts and formulas. It pays no or little attention to applied skills, concept development and problem-solving. These may not assist good understanding, concept development and applied skills for good outcomes. The researchers intend to introduce technology-enhanced instructional strategies into JSS system so as to assist students engage in practical, visual and interactive class activities that could boost concept development, digital science, applied skills and understanding of Pythagoras theorem. The researchers tend to apply technology-enhanced instructional strategy to see if it could boost students' interest in studying mathematics and enhance higher achievement.

Purpose of the Study

The general objective of the study is to investigate the effect of TEIS on students' conceptual understanding of Pythagoras theorem at JSS. Specifically, the study aims to:

1. Examine the impact of TEIS on students' conceptual understanding of Pythagoras theorem.
2. Investigate the effect of TEIS on male and female conceptual understanding of Pythagoras' theorem.

Research Questions

The following research questions guided the study;

1. What is the impact of TEIS on students' conceptual understanding of Pythagoras theorem at JSS?
2. What is the effect of TEIS on conceptual understanding of male and female students when taught Pythagoras' theorem at JSS?

Hypotheses

The following hypothesis was tested at 0.05 level of significance.

1. There is no significant difference in the mean achievement scores between students who taught Pythagoras theorem using TEIS and those taught using TIM.
2. There is no significant difference in the mean achievement scores between male and female students when taught Pythagoras theorem using TEIS and TIM.

Methodology

This study employed quasi-experimental research method of pretest-posttest control-experimental group to compare the mean scores of students who receive teaching by using TEIS and those who receive teaching with TIM. Quasi-experimental research design is suitable for this study because in a JSS setting, it may not be feasible to randomly assign students to different instructional strategy groups due to logistical and administrative constraints. Quasi-experimental design allows for non-random assignment.

Population of the Study

The population of the study consisted of 1,986 students from public JSS in Bichi local government area of Kano State. There are 53 JSS public schools in Bichi local government area. Two intact JSS 2 schools were used for the study. One school was assigned to experimental group with 16 males and 14 females. The other school was assigned to control group with 17 males, 15 females. These give total of 62 students. Stratified random sampling technique was used for sampling the two schools and all the students in the intact classes were used.

Instruments for Data Collection

Conceptual Understanding Test (CUT) that contains 20 multiple-choice items with options A to D was an instrument used for the study. Instrument was used for pre-test and post-test of experimental and control groups with total scores of 100%. Instrument was validated by two experts from mathematics department F.C.E (T) Bichi. Kano.

Cronbact Alpha was used to establish internal consistency and the reliability coefficient of 0.88 was obtained because the items have multiple responses.

Method of Data Collection and Analysis

The CUT was administered to all students to test conceptual understanding level of Pythagoras theorem. Then the experimental groups received teaching on Pythagoras theorem using TEIS. The control group also received teaching on Pythagoras theorem through TIM. CUT was administered to all students again after treatments. Three weeks were used for the study. Means and standard deviations were used to answer research questions while inferential Statistics of Analysis of Covariance (ANCOVA) was used to test the null hypotheses at 0.05 significant levels.

Results

Research Question 1: What is the impact of TEIS on students' conceptual understanding of Pythagoras theorem at JSS

Table 1: Mean, Standard Deviation and mean gain of students before and after treatment

GROUP	N	PRE_TEST		POST_TEST		MEAN
		π	SD	π	SD	GAIN
EXPERIMENTAL	30	42.70	11.00	80.33	9.29	37.63
CONTROL	32	44.38	8.74	45.22	7.50	0.84

Findings from Table 1, research question one informed that the experimental group pre-test has mean of 42.70 , and standard deviation of 11.00. The post-test mean scores was 80.33, with standard deviation of 9.29. Before teaching started, students achievement was very low, but after teaching was conducted the achievement of students improved greatly with mean gain of 37.63. In the control group, the pre-test mean was 44.38 while standard deviation was 8.74. The post-test result gave mean scores of 45.22 with standard deviation of 7.50. This shows that the control group received traditional teaching but no improvement even after treatment. This was because the mean gain was only 0.84 accordingly.

$H0_1$: There is no significant difference in the mean achievement scores between students who taught Pythagoras theorem using TEIS and those taught using TIM.

Table 2: Results of ANCOVA on Pythagoras theorem with TEIS and TIM
Tests of Between-Subjects Effects

Dependent Variable: PO_TEST					
Source	**Type III Sum of Squares**	***df***	**Mean Square**	**F**	**Sig.**
Corrected Model	19103.49	2	9551.75	133.14	0.01
Intercept	10942.50	1	10942.50	152.53	0.01
PR_TEST	11.35	1	11.35	0.16	0.69
GROUP	19031.65	1	19031.65	265.28	0.01
Error	4232.78	59	71.74		
Total	263279.00	62			
Corrected Total	23336.27	61			

Research Question 2: What is the effect of TEIS on conceptual understanding of male and female students when taught Pythagoras' theorem at JSS

Table 3: Mean Standard Deviation and mean gain of male and female students before and after treatment

GROUP	**GENDER**	**N**	**PRE_TEST** π	**SD**	**POST_TEST** π	**SD**	**MEAN GAIN**
EXPERIMENTAL	MALE	16	42.44	11.70	79.63	9.35	37.19
	FEMALE	14	43.00	10.59	81.14	9.29	38.14
CONTROL	MALE	17	45.00	9.45	45.53	7.90	0.53
	FEMALE	15	43.67	8.11	44.87	7.28	1.20

Table 3, research question two informed that from experimental group before treatment, male students has $\pi = 42.44$, S.D $= 11.70$ but after treatment $\pi = 43.00$, S.D$= 10.59$.. Female students have $\pi = 43.00$, S.D $= 10.59$ but after treatment $\pi =$ 81.14, S.D$= 9.29$. These indicate that the achievement of male and female students improved because of the treatment since the mean gains were 37.19 and 38.14 respectively. For the control group, before treatment, male students have $\pi = 445.00$, S.D $= 9.45$ but after treatment $\pi = 45.53$, S.D$= 7.90$. Female students have $\pi =$

43.67, S.D = 8.11 but after treatment $\pi = 44.87$, S.D= 7.28. These indicate that the achievement of male and female students did not improve because of the traditional teaching since the mean gains were 0.53 and 1.20 respectively.

H0$_2$: There is no significant difference in the mean achievement scores between male and female students when taught Pythagoras theorem using TEIS and TIM.

Table 4: Results of ANCOVA for male and females experimental and control group

Tests of Between-Subjects Effects

Dependent Variable: PO_TEST

Source	Type III Sum of Squares	*df*	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	19123.18[a]	4	4780.79	64.68	0.00	0.82
Intercept	10959.53	1	10959.53	148.27	0.00	0.72
PR_TEST	10.34	1	10.34	0.14	0.71	0.01
GROUP	19031.87	1	19031.87	257.49	0.00	0.82
GENDER	2.96	1	2.96	0.04	0.84	0.001
GROUP * GENDER	17.16	1	17.16	0.23	0.63	0.01
Error	4213.10	57	73.91			
Total	263279.00	62				
Corrected Total	23336.27	61				

In Table 4, F (1, 57) = 0.23; P = 0.63 > 0.05. So the null hypothesis is maintained. There is no significant difference in the mean achievement scores between male and female students when taught Pythagoras theorem using TEIS and TIM.

Discussion

From research question one, hypothesis one, results analyzed shows that, before treatment experiment and control groups achievement was below average. But after the treatment was carried out, the experimental group (received teaching using TEIS) achievement was very good. In the control group there was no or very little improvement even after the teaching was carried out with the traditional teaching method. These gave a significant difference in the mean achievement scores of students that taught Pythagoras theorem using TEIS and those taught with TIM. This agreed with findings of Oyebade and Oyebade (2018) who study on the impact of technology-based instructional strategy on students achievement in Pythagoras theorem; in which their findings show a significant different in the mean achievement scores of students taught Pythagoras theorem using technology-based instructional strategy and those taught using traditional teaching method.

Analysis from research question two, hypothesis two shows no significant difference in the conceptual understanding of male and female students when taught Pythagoras theorem using TEIS and TIM for both pretest and post-test. This was in line with the study of Cakir and Ozturk (2018) who research findings shows no significant difference in the mean achievement scores of male (mean = 80.56) and female (mean = 79.21) students who taught Pythagoras theorem using computer-assisted instructions and those taught using traditional teaching method.

Conclusion

Findings from this stud indicate that, the use of TEIS for teaching mathematics could encourage students to study with ease by reducing the load and guide them for application and utilization of mathematics skills at school and outside the school setting. It could educate students for problem-solving and encourage gender studies. Students could be encourage to advance their studies in professional fields such as medicine, pharmacy, aviation, survey, engineering just to mention but few. Therefore TEIS should be encourage and applied in teaching Pythagoras theorem, mathematics and science at all level.

Recommendations

This study recommends as follows;

1. TEIS should be applied by teachers in teaching Pythagoras theorem and mathematics at all level because it was found to improve students' academic achievement and gender. Studies.
2. Curriculum planners and stakeholders should co-operate innovative activity based pedagogical strategy like TEIS at secondary school level.
3. Professional bodies such as Mathematical Association of Nigeria (MAN), Science Teachers Association of Nigeria (STAN) together with federal ministry of education should organize seminars, workshops and symposia on the use of TEIS at secondary school level.

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