EFFECT OF SIMULATION-GAMES STRATEGY ON RETENTION AND PERFORMANCE IN TRIGONOMETRY AMONG SENIOR SECONDARY STUDENTS IN NIGER STATE, NIGERIA

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Abstract
*This study investigated the effect of Simulation-Games Strategy on Retention and Performance in Trigonometry among Senior Secondary Students in Niger State, Nigeria. **A** Non-equivalent Control Group design with retention follow-up which used pre-test post-test control group (retention test) design was adopted. The study used SSII students with a population of 20,154 and sample size of 190 selected from four schools randomly assigned to experimental and Control group(s). Two research questions and two hypotheses were formulated and investigated. Forty items research instruments of Trigonometry Performance Test (TPT) and Trigonometry Retention Test (TRT) with reliability coefficient of 0.75 and 0.71 respectively were used for data collection. Research questions were analysed using means, mean and standard deviations. t-test statistics was used for hypotheses testing at $\alpha = 0.05$ level of significance. The results indicated that, there was significant difference among the mean retention ability and performance of students taught Trigonometry using Simulation-Games strategy and conventional teaching method; and that the Simulation-Games strategy was significantly more effective than the conventional teaching method. Based on the findings it is recommended among others that the use of Simulation-Games strategy for teaching Mathematics and Trigonometry should be encouraged in Nigerian secondary schools to improve their retention ability and performance in Trigonometry*

Keywords: Simulation-Games, Performance, Retention and trigonometry

Introduction

Trigonometry is a branch of Mathematics which deals with indirect measurement as in plane geometry and surveying; and concerned with the properties of trigonometric functions and their application to the determination of the angles and sides of right-angled triangles (Williams, 2019; Obeng, Banson & Owusu, 2024; Bolaji, Kajuru, Ibrahim & Momozoku, 2017). According to Onah (2024), trigonometry account for 35% of secondary mathematics curriculum content in Nigeria. It is one of the main branches of pure mathematics. Bolaji, Kajuru, Ibrahim and Momozoku (2019); Mailizar, Johar and Hidayat (2025) define trigonometry as the branch of mathematics that studies relationship involving lengths and angles of triangles. Bolaji et al (2017) stated that trigonometry is one of the contents offered in Senior Secondary School Mathematics Curriculum. Its study involves the acquisition of practical skills which enables the learners to acquire the skills in visual, verbal, logical representation and applications (Onah, 2024; Ngeobo, Madonsela & Arijlall, 2019; Bolaji et al, 2017). Bolaji et al (2019); Onah, (2024) and Mailizar et al (2025) stated that trigonometric functions are widely applied in astronomy, geography, chemistry, physics, mechanical and electrical engineering, computers and technologies, music and acoustic as well as ecology and biology; and it is the foundation of surveying and architecture (Onah, 2024; Bolaji et al, 2019). Mastering problem-solving in trigonometry are great assets to any secondary students as such skills are the tools for developing critical and logical thinking that can facilitate the learning of mathematics and other science subjects.

According to Bolaji et al (2017) and Williams (2019), students come across contents in Trigonometry in their Senior Secondary One (SSI). This is believed to have caused the difficulties students generally to encounter when solving problems in Trigonometry. Studies have shown that Trigonometry has been identified as one of the most difficult topics teachers find hard to explain for easy comprehension by the students (Fui, Shahrill, & Mundia, 2015). Furthermore, teachers often lack mastery of Trigonometry and their use of use of traditional talk and chalk methods is found to be an ineffective instructional strategy (Damayanti, Santi & Hima, 2024; Fererde, Mihrka, Avele & Arara, 2024), This could be the reason why students' fear and shun away from the learning of Trigonometry leading to their persistent low performance particularly in Trigonometry and Mathematics in general.

Inekwe (2002) view performance as the quality of results produced by students as reflected in the quality of their examination scores. It has to do with achievement of success in a given task or obligation. Therefore, in order to have

better students' performance in Trigonometry, there is need to motivate the students positively towards the study of Trigonometry so that they can retain the contents treated.

Retention refers to a student's ability to recall material immediately or after a specific time interval in an assessment or examination. It requires a student to reproduce correctly what has been previously learned (Bichi, 2002). Before students can retain a lesson taught, it must have meant and be interesting to them. The amount of retention is directly affected by the degree of importance they attach to the subject which is also affected by the instructional strategy applied during the lesson delivery which in turn influence their performance. To improve academic achievement and retention of contents treated in trigonometry, its teaching and learning requires activity oriented and practical approach to facilitate retention and performance by the students (Kajuru, Bolaji & Salihu, 2012). Several activity-based instructional strategies have been suggested by researchers and Mathematics educators to improve students' performance in Mathematics generally. Thus, for Trigonometry to be taught effectively in secondary schools, Simulation-Games strategy has been advocated by Kajuru et al, (2012) as Simulation games had potentials to enhance students' performance, increase retention ability to learn and raises their interest in learning. Barti and Soni (2024) and Caniglia (2019) define simulation-games as series of instructional designs that use elements from simulation and gaming. Bello, Ibi and Bukar (2016) define simulation-games as instructional scenarios where the learner is placed in a 'world' defied by the teacher. They represent a reality within which students interact. The teacher control the parameters of this 'world' and uses it to achieve the desire instructional results. In addition, students experience the reality of the scenario and gather meaning from it.

A simulation is a form of experiential learning. It is a situation that fits well with the principle of student-centered and constructivist learning and teaching. Simulation-games are characterized by their non-linear nature by their controlled ambiguity within which students must make decisions (Bello et al, 2016, Bolaji et al, 2017; Barti & Soni, 2024). The innovativeness and commitment of the participants usually determine the success of simulation-games. When students use a model of behavioral to gain or better understanding of that behaviour, they are doing a simulation. Barti and Soni (2024) stated that simulation-games allow students to learn mathematics concepts in practical and interesting way which offer a dynamic and interactive learning environment. Studies revealed that student's performance in mathematics is enhanced by simulation-games. It enhances students' computational skills, conceptual grasp of mathematical concepts, capacity to visualize abstract ideas, willingness to experiment with variables and students participate in reflective processes, self-mentoring, self-awareness and increase success were the results of the simulation-games (Caniglia, 2019; Ibrahim & Abu-Hamaid, 2017; Bolaji et al, 2017). Students are motivated, have positive attitude and increased interest and retention of mathematical concepts. Games promote and help creative solution to problem-solving. Games promote significant changes and mental reinforces activities (Barbieri, Barbieri & Capone, 2021). Therefore, embedding mathematics learning into Simulation games may enhance students' motivation and learning performance in Mathematics.

Simulation games teaching strategy will make teaching and learning more motivating, interesting, make the classroom environment lively, arouse the interest of the learners and sustained their interest and attention throughout the teaching and learning period. It is activity oriented and learner centered approach. In studies by researchers, simulations and games are believed to improve academic achievement and increase retention abilities as supported by evidence from Emmanuel and Odeyi (2024), whose result showed that students taught trigonometry using triangle solver games retained more than those taught with conventional method. Ani (2025) stated that students taught trigonometry using mathematics card games had significantly retained better than their counterpart taught trigonometry using other methods. Canigla (2019) stated that the experience of simulation can increase long term retention and memory of material learned showing the teaching strategy have considerable impact in improving retention ability in students at secondary school level. Idris (2016) study discovered that the ability to remember takes place more effectively when experiences are passed across to the learner through appropriate instructional method such as simulations and games.

In addition, Kajuru, Bolaji and Kauru (2014) carried out study on impact of simulation-Games on students' performance and found that there was significant difference in the performance scores of the students taught Trigonometry concepts due to treatment. Dorji and Rigdel (2024) which indicated that student's experimental group had positive significantly higher mathematics achievement than control group demonstrating the effectiveness of games and simulation in learning ($P<0.05$). In the studies conducted by Emmanuel and Odeyi (2024), their result revealed that students taught trigonometry using triangle solver games achieved higher and retained more than those taught with conventional method. Onah (2024) study showed that students taught using trigoludo games strategy achieved higher and retained more in trigonometry than their counterpart in control group. In addition, Ani (2025) study revealed that the student's trigonometry using mathematics

card games had significant academic achievement and retained better than their counterpart taught trigonometry using other methods

This finding agreed with the findings of Idris (2016) and that of Piu, Fregole and Barbieri, (2016) who found that students who learned geometrical concepts through simulation games had a higher level of both content retention and level of abstraction compared with those in control group. Simulation-Games can be done with board games, computer assisted board games, or fully computerized environments. Bolaji et al (2019) see Simulation games as board games which are sold in the market or those different types of games made in the Mathematics Laboratory by teachers and students for classroom use. Examples of games include Geometric, Fraction, Trigonometric, Numbers, the Fours', Ludo, Snakes and Ladders, "Ayo" and others. Such games essentially try to lay emphasis on processes and relationships (Ojaleye & Niyi, 2008) and thereby concluded that not only do such games allow students to discuss and take practical decisions, but they also facilitate the development of the imagination. Students usually find them very stimulating and motivating. The use of simulation games in teaching-learning situation is since simulation games provide fascinating challenges to learners and add interest, activity and novelty to the lesson. In addition, simulation-game is intended to help students translate mathematics principles, concepts, and theories into practice, thus making the learning process an interesting, interactive, and long-lasting experience (Bolaji et al, 2017). The purpose of simulation game is not for winning but for developing the spirit of the game, that is, the spirit of tolerance, planning and give and take. The educational benefit of simulation and gaming is that students develop expert behaviors such as pattern recognition, problem solving, qualitative thinking, and principled decision-making as their individual expertise with games increase. Students' performance, skills, and ability to explore, experiment and collaborate increased by playing games. In addition, Bolaji et al (2017) stated that with realistic games, students not only become smarter and intellectually engaged but also realize their desire for hard fun, delayed gratification, rewards, making right decisions, participation, depth of understanding, challenge, and using their pattern recognition and problem-solving skills. They concluded that both resource-deprived and resource-affluent students make significant learning gains after playing well designed simulation games; their spatial abilities and cognitive development increases after playing with simulation games among both genders.

Therefore, game-based teaching allowed students opportunity to actively participate in their learning creating room for higher academic achievement and retention of what they were taught (Ku, Chen, Wu, Lao, & Chan, 2014). Hence, this study investigated the effect of Simulation-Games strategy on Retention and Performance in Trigonometry among senior secondary students in Niger State, Nigeria.

Research Questions

The following research questions were posed to guide the study:

1.What is the difference in the mean retention ability scores of students taught Trigonometry using Simulation-Games strategy as compared with those taught using conventional method?

2.What impact did the use of Simulation-Games strategy have on the students' performance in Trigonometry as compared with their counterpart taught using conventional method?

Hypotheses

The following null hypotheses were formulated and tested at 0. 05 level of significance:

1.Ho_1: There is no significant difference among the mean retention ability scores of students taught Trigonometry with Simulation-Games strategy and those taught using conventional teaching method.

2.Ho_5: There is no significant difference among the mean performance scores of students taught Trigonometry using Simulation-Games strategy and those taught using conventional teaching method.

Methodology

Research Design: The study employed a Non-equivalent Control Group Design with Retention Follow-up. The experimental group received the Simulation-Games Strategy intervention after the pre-test, while the control group received the conventional teaching method

Area of the Study: The study was carried out among senior secondary students in Niger state-Nigeria

Population, Sample and Sampling Technique: The populations of the study comprised of all senior secondary two (20,154) students in Niger state. A multi-stage stratified random sampling procedure was used in selecting the sample for the study. The first stage was done by grouping the schools into clusters of three senatorial zones. The second stage was done by grouping into clusters of seven education zones including the number of schools in each education zone and their respective local government areas. Three education zones of Kontagora, Kutigi and Bida were selected from the seven

education zones through stratified random sampling procedure. Out of these three education zones, Kontagora education zone was selected through random sampling procedure. There are ten senior secondary schools in Kontagora education zone out of which four were randomly selected for the study using balloting technique. The first two picked schools served as experimental group while the third and fourth picked schools served as served as control group respectively through balloting method. A total of one hundred and ninety (190) students were selected as sample for the study. There are ninety-seven (97) students in experimental group and ninety-three (93) students in control group. In determining the sample for the study, the researcher adopted Sambo (2008) recommendation that the sample size N≥30 can be used to establish a relationship between two groups in experimental research.

Instruments and reliability of instruments: Two research instruments were used for data collection which were Trigonometry Performance Test (TPT) and Trigonometry Retention Test (TRT) each containing forty multiple choice questions with option A to E. The face and content validity of the TPT and TRT test items were found to be within the ability level of the students, free from ambiguities, covered the content area and measured what is expected to measure by the three mathematics educators that moderated. They were pilot tested and found with reliability coefficient of 0.75 and 0.71 respectively determined using Cronbach alpha (α_{20}).

Procedure for Data Collection: After teaching for six weeks and administration of treatments to the experimental group; the research assistance administered the instruments to the two groups under the same conditions and retrieved them from the students after forty minutes time allocated for the test lapsed. Both pre-test and post-test scripts were marked, scored and the results recorded.

Procedure for Data Analysis: The Statistical tools of mean; mean difference and standard deviation were used to answer the research questions while t-test statistics was used for hypotheses testing at $\alpha = 0.05$ level of significance.

Results

The data collected from this study were analysed using descriptive statistics of means, standard deviation and standard error to answer the research questions and inferential statistics of t-test was used for the hypotheses testing at $\alpha = 0.05$ level of significance. The detail of the analyses were as follow:

Research Question one: What is the difference in the mean retention ability scores of students taught Trigonometry using Simulation-Games strategy as compared with those taught using conventional method? To answer this research question, the results was presented in Table 1.

Table 1: Means, Standard Deviations and Mean Differences of the Simulation-Games Strategy and Conventional Method in Trigonometry Retention Test.

Strategy	N	Mean	SD	Df	Mean Diff
Simulation-Games	97	66.60	11.17		
Conventional				188	28.96
	93	37.64	18.53		

Table 1: indicated that Simulation-Games strategy has a mean retention score of 66.60 with standard deviation of 11.17 compared with conventional Method having a mean retention score of 37.64 with standard deviation of 18.53. The mean difference between the two groups was 28.96 which could be considered as significant.

Research Questions two: What impact did the use Simulation-Games strategy have on the students' performance in Trigonometry as compared with their counterpart taught using conventional method? To answer this research question, the results was presented in Table 2.

Table 2: Mean, Standard Deviation, Standard Error and Mean Differences of the Simulation-Games Strategy and Conventional Method in Trigonometry Performance Test

Strategy	N	Mean	SD	Df	Std Error	Mean Diff.
Simulation-Games	97	54.86	10.67		1.26	
				188		11.76
Conventional	93	43.10	14.45		1.70	

Results in Table 2 showed that the mean performance score of Simulation-Games strategy was 54.86 with standard deviation of 10.67 and the mean performance scores of the conventional method was 43.10 with standard deviation of 14.45. The mean difference between Simulation-Games strategy and Conventional Method was 11.76. This shows that there was impact of treatment on academic performance of the students exposed to Simulation- Games teaching strategy employed during the study.

Hypotheses Testing

Based on the study, the following null hypotheses were formulated and tested at 0. 05 level of significance:

Ho_1: There is no significant difference in students mean retention ability scores towards Trigonometry when exposed to Simulation-Games strategy and those taught using conventional teaching method. To test the hypothesis t-test statistics was used as in Table 3.

Table 3: t-test analysis of difference in the mean retention ability scores of students taught Trigonometry with Simulation-Games strategy and those taught using conventional teaching method.

Group	No	Mean(X)	St dev	MD	df	t-cal	P-value	Remark
Experimental	97	66.60	11.17					
				28.96	188	8.25	0.00*	Significant
Control	93	37.64	18.53					

*Significant at P≤0.05

Table 3 showed a calculated t-cal of 8.25 and the calculated p-value was 0.00 which was less than alpha value of 0.05. it means that there was a significant difference in the retention ability between the experimental and control groups. Based on this result, the null hypothesis of no significant difference was rejected and the alternative hypothesis is upheld. This implies that there was significant difference in the mean retention ability of students taught Trigonometry concepts using Simulation-Games strategy as compared with the conventional teaching method.

Ho_2: There is no significant difference among the mean performance scores of students taught Trigonometry using Simulation-Games strategy and those taught using conventional teaching method. To test the hypothesis, t-test statistic was used as presented in Table 4:

Table 4: t-test analysis *of difference in the mean performance scores of students taught Trigonometry with Simulation-Games strategies and those taught using conventional teaching method.*

Group	No	Mean(X)	St dev	MD	df	t-cal	P-value	Remark
Experimental	97	54.86	10.67					
				11.76	188	5.20	0.001*	Significant
Control	93	43.10	14.45					

*Significant at P≤0.05

Table 4 above shows a t-cal of 5.20 with df of 188 and P=0.001. Since P≤0.05, it means that there was a significant difference in the academic performance between the experimental and control groups. The null hypothesis of no significant difference is therefore rejected. It implies that the difference in the means scores of the two groups was significant. Therefore, the alternative hypothesis is retained

Discussions

The objective of the study was set to investigate the effect of Simulation-Games Strategy on Retention and Performance towards Trigonometry among Senior Secondary Students in Niger State, Nigeria. The explanation of the findings obtained from the hypotheses tested and supported by other related studies: The findings from the analysis of Ho_1 in Table 3 showed that there was statistically significant difference between the mean retention ability of students taught Trigonometry concepts using Simulation-Games strategy as compared with the conventional teaching method. This agrees with the studies conducted by Emmanuel and Odeyi (2024), whose result revealed that students taught trigonometry using triangle solver games retained more than those taught with conventional method. In another study by Ani (2025) revealed that students taught trigonometry using mathematics card games had significantly retained better than their counterpart taught trigonometry using other methods. Canigla (2019) stated that the experience of simulation can increase long term retention and memory of material learned showing the teaching strategy have considerable impact in improving retention ability in

students at secondary school level. The result supported that of Idris (2016) who discovered that the ability to remember takes place more effectively when experiences are passed across to the learner through appropriate instructional method. Result in Table 4 of hypothesis two showed statistically significant difference meaning that there was significant difference in the mean performance scores of students taught Trigonometry with Simulation-Games strategy and those exposed to conventional teaching method. This confirms the findings of Kajuru, Bolaji and Kauru (2014) that there was significant difference in the performance scores of the students taught Trigonometry concepts due to treatment. This finding is in line with the work of Dorji and Rigdel (2024) which indicated that student's experimental group had positive significantly higher mathematics achievement than control group demonstrating the effectiveness of games and simulation in learning ($P<0.05$). The studies conducted by Onoh (2024) showed that students taught using trigoludo games strategy achieved higher and retained more in trigonometry than their counterpart in control group. In addition, Ani (2025) study revealed that the student's trigonometry using mathematics card games had significant academic achievement and retained better than their counterpart taught trigonometry using other methods

Conclusion

The study indicated that the use of the use of Simulation-Games strategy in the teaching of Trigonometry enhances higher level of academic performance and increased retention ability towards Trigonometry among senior secondary (SSII) students on the experimental group than those in conventional group. When developing or adapting games for instructional purposes, look for existing gaming strategies which can be used for one's particular purposes. Use a highly visual simulation game which includes all participants to help understand, address, and resolve group decision-making. Make sure ones game has a way of ending so the satisfaction of the learner may be maximized. Gaming used for instructional purposes should not be overly complex for it will help promote interest in instructional materials as the learner's gaming abilities increase. Always use student centered approach to enhance students' performance and retention in trigonometry teaching and learning.

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