ENHANCING SECONDARY SCHOOL STUDENTS' RETENTION IN GEOMETRY THROUGH THE USE OF GEOTAN INSTRUCTIONAL SOFTWARE PACKAGE

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Abstract
This study determined the effect of GeoTAN Instructional Software Package (GISP) on the Secondary School students' retention in geometry. Two research questions and three hypotheses were formulated, and the hypotheses tested at 0.05 level of significance. Quasi-experimental (non-equivalent control group) design was adopted. The researcher sampled 240 Senior Secondary School year two (SS2) students in public secondary from a population of 33,074. Geometry Achievement Test (GAT) which was validated and has a reliability index of 0.87 determined with K-R 20 method was used to collect data. The teaching tool used in the experimental group was GISP which has a content validity index of 0. 82, determined with Kendall's W method. Mean and Two-way Analysis of Covariance (ANCOVA) were used to analyze the data. Analysis of data showed that method of teaching has significant effect on students' retention in geometry $F(1, 235) = 62.232$, $P < 0.0005$; gender has no significant influence on students' retention in geometry $F(1, 235) = 0.707$, $P = 0.401$and the interaction effect of method and gender on students' retention score in geometry was not significant $F(1, 235) = 0.159$, $P = 0.691$. Based on the findings, it was recommended that GISP could be used to teach geometry in order to increase secondary school students' retention in geometry.

Keywords: GeoTAN Instructional Software Package, Geometry and Retention,

Introduction

Geometry is one of the five themes in Mathematics in the senior secondary school Mathematics curriculum which was done in order to facilitate and simplify the teaching and learning of Mathematics in secondary schools in Nigeria(Nigerian Educational Research and Development Council, NERDC, 2007)). Geometry is defined by Kurumeh, Obarakpo, Odoh and Ikyereve (2016) as the study of size, shape, angle and surfaces of 2dimensional and 3-dimensional shapes. Jacob, Decl, Bolaji, Kajuru and Musa(2017) stated that geometry is widely applied in various areas of life, such as Computer Aided Design (CAD), modeling, robotics, medical imaging, computer animation and visual presentation.

Notwithstanding the importance of geometry, the achievement of secondary school students in geometry is poor. This view is buttressed by the findings of Mathematics Chief Examiners in WASSCE in Nigeria which reported that candidates in WASSCE have consistently showed significant weakness in geometry (WAEC Chief Examiners' Report, 2016 & 2017). Fabiyi (2017) corroborated the report of WAEC Chief Examiners in Mathematics and reiterated that chord property, circle theorem and tangent to a circle were among the concepts in geometry that students find difficult to learn. Similarly, Adegun and Adegun (2013) reported that secondary school students encounter difficulties in geometry, hence, perform poorly in it during lesson and external examination like WASSCE, NECO, among others. It was on this

premise Usman, Wishishi, Gambari & Olayinka (2017); Adie et al. (2020) conducted a study and reported that teaching method employed by Mathematics teachers was responsible for the poor achievement in geometry.

Fundamentally, science and Mathematics teachers in Imo State are conversant with conventional method. The reason for this, according to the submission of Ojukwu(2016) is that society placed too much prominence on students' performance in examinations, hence, teachers rush through the scheme of work in order to cover the curriculum so as to make students pass examination. For the purposes of this study, Conventional Method (CM) is described as the teaching method used by the classroom teacher to teach the students in the control group which is not influenced by the method of teaching as used in the experimental group(Njoku, 2021). It is, therefore, correct to claim that students encounter difficulties with Conventional Method as it does not allow them to participate actively in the lesson because it is basically teacher centered, hence, students perform poorly in geometry.

In view of the foregoing, poor achievement and difficulties students encounter in geometry presuppose that students do not retain geometry concept after lessons. Retention according to Okonkwo (2012) is defined as the ability of one to store learnt information and recall what was learnt after a period of time. This definition suggests that retention occurs if a learner repeats an earlier acquired behaviour after an interval of time with less or without error. Based on this, it can be concluded that good academic achievement tends to result where there is an effective retention of information. This assertion has accentuated to studies on retention that have shown that retention is an important factor in students' achievement (Akor, 2015). For the purposes of this study, retention is defined as the capacity to store or retain the knowledge of geometry (chord property, circle theorem and tangent to a circle) learnt in the long term memory and ability to repeat the earlier acquired behaviour after an interval of 21 days. Iji, (2010) stressed that achievement is a function of retention. This implies that achievement is tied to retention and is necessary for students who are periodically tested to ascertain how much they have learnt. Hence, method of presentation of learning experiences to the learners becomes absolutely consequential as it affects the capacity to store and ability to recall knowledge. Chauhan in Okafor and Igwe (2016) concluded that over learning, meaningfulness and organization of subject matter; and principle of learning by doing encourage retention. This presupposes that method of teaching that is interactive and activity-centred enhances retention. Ngwu(2015) supported this position and reiterated that the method of teaching used in delivering instruction largely determines the ability of the students to retain what they have been taught by the teacher. In this regard, Ogbu (2015) suggested the adoption of teaching methods that would involve students in the teaching and learning process by engaging them in interactive activities. Interestingly, on strength of the foregoing, the instructional software package advocated in this study is researcher-developed instructional software package called GeoTAN Instructional Software Package (GISP). This is because GISP is designed to present concepts to learners in an interactive manner.

GISP is an instructional computer software, developed by the researchers for the purpose of delivering instructions on chord properties, circle theorems and tangent to a circle to SS2 students which has instructional interactivity, visualization, audio and animation components. Its features include instructional stages/phases, such as presentation of introduction, list of lessons, specific objectives of each lesson, test on previous knowledge, content/activity development, text, narration, animation, lesson evaluation and summary. Furthermore, in its lesson evaluation, GISP gives immediate feedback to students and shows learners whether the option selected is right or wrong including navigation from one link to another using Home, Next, Back and Exit Buttons. The theoretical framework that underpinned the development of GISP was cognitive theory of multimedia learning. The features of GISP are in line with the submission of NERDC(2007) and National Council of Teachers of Mathematics (NCTM, 2013) that computer

system be used for instructional delivery in Mathematics particularly the difficult and abstract concepts.

Studies on retention in Mathematics and other fields with respect to instructional software package have been carried out in the past. In a study conducted by Giginna, (2013), it was reported that instructional software package enhanced retention of learned concepts more than conventional teaching method in chemistry. On the contrary, Robert (2014) reported that students who were taught Chemistry using instructional software package did not retain what they learnt more than students taught with conventional teaching method. In another related study carried out by Amosa, Akawo, Eli and Ughovwa (2014) reported that students taught Biology with conventional teaching method had better retention than those taught with instructional software. However, the study conducted by Olojede (2016) reported that instructional software package increased the students' retention in geometry. The inconsistency in findings, notwithstanding, there is a common view that retention is an important factor in students' academic achievement. In light of this, it becomes expedient to conduct more research on the use of instructional software package in teaching geometry in order to clear this inconsistency in finding and also determine the influence of gender on retention scores of students in geometry.

Overtime, gender consideration in educational research has taken center stage because of its influence on academic achievement and retention. Gender is referred to as the social or cultural construct, characteristics, behaviours and roles which society ascribes to females and males (Nzewi, 2010). Basically, these attributes or roles are social constructions relative to cultural practices. This is in line with the observation of Ugwuanyi (2012) that these attributes are socially constructed roles which are transmitted through socialization. In the context of teaching and learning, Erinosho in Nzewi (2010) submitted that Science, Technology, Engineering and Mathematics(STEM) materials used in Nigerian classrooms are absolutely gender biased. However, Nzewi in Okolie (2018) opined that girls have the capacity to learn STEM subjects as much as boys under the same condition but it all depends on the brain. Studies have been carried out to investigate the effect of instructional software package teaching methods on students' retention in Science and Mathematics. For example, the study by Alhassan (2012) on effects of Computer Assisted Instructional package on achievement and retention of junior secondary school students in geometry revealed that male students performed better and retained information more than female students when taught geometry using Computer Assisted Instructional package. Similarly, Egbunu, Agbo-Egwu and Anyagh (2017) conducted a study to ascertain the effect of Computer Aided Instructions (CAI) on students' retention in Mathematics and reported that boys retained better with CAI. However, the studies conducted by Gambari, Ezenwa and Anyanwu (2014) and Ramatu, Oluwole and Ahmed (2015) to determine the Computer Assisted Instructional Package on achievement and retention. Their findings showed that gender had no significant influence on students' retention. These conflicting findings necessitated the present study with a view to contributing and stating the actual situation. This study is, therefore, carried out to determine the effect of GISP on students' retention in geometry when taught with GISP. Against this background, GISP was developed and validated for the purpose of teaching geometry in secondary schools and its effect is also determined on retention of secondary school students in geometry.

Purpose of the Study

The purpose of the study was to determine the effect of GISP on secondary school students' retention in geometry. Specifically, the purpose of the study was to determine the:

1. mean retention scores of secondary school students taught geometry using GISP and those taught using CM.
2. mean retention scores of male and female students taught geometry using GISP.

3. interaction effect of teaching method and gender on mean retention scores of students in geometry.

Research Question

1. What are the mean retention scores of students who were taught geometry using GISP and those taught using CM?
2. What are the mean retention scores of male and female students who were taught geometry using GISP and those taught using CM?

Hypotheses

1. There is no significant difference between the mean retention scores of students who were taught geometry using GISP and those taught using CM.
2. There is no significant difference in the mean retention scores of male and female students who were taught geometry.
3. There is no significant interaction effect of teaching methods and gender on mean retention scores of students who were taught geometry.

Research Methodology

The quasi-experimental design, particularly, the non-equivalent control group design consisting of a pre-test, post-test and delayed post-test was employed in the present study. It is a research design whereby two or more intact groups that are not equivalent, are randomly assigned to treatment groups and the groups are subjected to pretest before the treatment and posttest after the treatment (Nworgu, 2015).The population of the study was 33074 (15325 males and 17749 females) Senior Secondary two (SS2) in public secondary schools in Imo State, Nigeria out of which a sample of 240 SS2 students was selected through multistage sampling procedure involving purposive sampling and simple random sampling techniques by balloting. The students in experimental group were taught geometry with GISP and Lesson Plan on Geometry was used to teach the students in control groups. The following application software were used in the development of GISP: Cinema 4D, Macromedia Flash 8, Macromedia Fireworks 8, Microsoft Word and Adobe Audition. The assistance of a professional computer programmer was sought and the computer programmer perfected the development of GISP. GISP was validated by educational technologists, computer programmers and Mathematics specialists. This was followed by a pilot study. Geometry Achievement Test (GAT) was the instrument used for collection of data in this study. GAT was developed by the researcher based on the topics chosen for the study. It consists of two parts, I and II. Part I is the preliminary part which made provisions for getting bio-data of the participants. Part II contains 40-item multiple-choice questions with four response alternatives A-D. GAT was subjected to face and content validity, and item analysis. For item analysis, all items within the range of difficulty indices of 0.30 to 0.70 was selected. Similarly, all items whose discrimination indices fall within the range of 0.30 to 1.00 were selected. For the distractor indices, the options with distractor indices greater than zero were selected. Thereafter, the increasing order of difficulty indices were used in arranging GAT items.

GAT was subjected to reliability test. In doing this, 30 SS3 students were randomly selected outside the study area and GAT was administered to them. Kudar-Richardson (KR-20) was used test the reliability and it revealed a reliability coefficient of 0.91 for internal consistency. For the fact that the instrument would be used twice, there was need to establish the temporal stability of GAT. Hence, test retest was used to established it. Therefore, GAT was administered again to the same students after two weeks. Pearson Product Moment Correlation was employed to obtain correlation co-efficient and which gave correlation co-efficient of 0.92. Based on these indices, GAT was considered adequate for the research study. GAT was administered on the students before the treatment started as pre-test and after the treatment it was administered on the students as post-test. After a period of 21 days, the post-test GAT was

re-arranged starting with the items from the bottom to the top, the section's names were changed from section A and B to section X and Y and the options to each of the items swooped; and administered to the same students as delayed post-test.

The regular Mathematics teachers in the experimental group were coordinated by the researcher on how to use the GISP in teaching geometry which lasted for one week. Thereafter, they were given instructional guide and a compact disk containing GISP. On the other hand, the regular Mathematics teachers in the control group were giving the validated copy of Lesson Plan in Geometry. In the schools sampled for the study, three intact classes were randomly assigned to the experimental group and another three intact classes to the control group. Before the treatment started, GAT was administered to the students as pre-test with the help of research assistants (regular Mathematics teachers), and the scores obtained were recorded by the researchers. Teaching using the GISP was the treatment in experimental group which lasted for five weeks. Prior to the commencement of the treatment, a 40-minute introduction on how to use GISP was given to the students in experimental group which was aimed at familiarizing them with GISP? The extraneous variables that would have adversely affected the conduct of the experiment and the results obtained thereof were controlled. The variables are teacher factor, hawthorne effect, possible intermingling of participants, initial group difference, test knowledge and researcher bias. On the analysis of data, outliers were removed in the data and thereafter computed the mean, standard deviation of achievement scores. The research questions were answered with mean and standard deviation while Two-way Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance.

Results

Research Question 1: What are the mean retention scores of students who were taught geometry using GISP and those taught using CM?

Table 1

Mean retention scores of students taught geometry using GISP and Conventional Method.

		Post-test		Delayed Posttest		Mean($\overline{X}$)
Source of Variation	**N**	$\overline{X}$	**SD**	$\overline{X}$	**SD**	**Gain**
GISP	116	61.47	8.50	66.61	7.25	5.14
CM	124	43.64	8.21	44.47	9.58	1.47

Table 1 shows that students who were exposed to GISP had mean post-test score of 61.47 with a standard deviation of 8.50 at the post-test and mean delayed post-test score of 66.61 and standard deviation of 7.25 at the delayed post-test while their counterparts who were taught using CM had mean post-test score of 43.64 with a standard deviation of 8.21 and mean delayed post-test score of 44.47 with standard deviation of 9.58 at the delayed post-test. Mean gain retention scores of 5.14 and 1.47 for students who were exposed to GISP and CM respectively indicating that students who were exposed to GISP had higher mean retention scores than their counterparts exposed to CM.

Research Question 2: What are the mean retention scores of male and female students who were taught geometry using GISP and those taught using CM?

Table 2
Mean retention scores of male and female students taught geometry using GISP and Conventional Method.

Source of variation	Gender	N	Type of Test	$\overline{X}$	SD
GISP	Male	54	Delayed Post-test	66.65	7.67
			Post test	61.47	8.50
			Mean Gain	5.18	
CM	Male	57	Delayed Post-test	44.75	10.37
			Post test	43.63	9.24
			Mean Gain	1.12	
			Total	111	
GISP	Female	62	Delayed Post-test	66.58	6.92
			Post test	61.63	8.33
			Mean Gain	4.95	
CM	Female	67	Delayed Post-test	44.22	8.92
			Post test	43.40	8.21
			Mean Gain	0.82	
			Total	129	

The result presented in Table 2 reveals that the male students exposed to GISP had a posttest mean retention scores of 61.47 with a standard deviation of 8.50 and a delayed posttest mean retention scores of 66.65 with a standard deviation of 7.67. The mean gain retention scores of male students exposed to GISP was 5.18. The female students exposed to GISP had a posttest mean retention scores of 61.63 with a standard deviation of 8.33 and a delayed posttest mean retention scores of 66.58 with a standard deviation of 6.92. The mean gain retention scores of female students exposed to GISP was 4.95. This result suggests that male students exposed to GISP had slightly higher retention than their female counterparts exposed to GISP.

Table 2 reveals also that male students exposed to CM had a posttest mean retention scores of 43.63 with a standard deviation of 9.24 and a delayed posttest mean retention scores of 44.75 with a standard deviation of 10.37. The mean gain retention scores of male students exposed to CM was 1.20. The female students exposed to CM had a posttest mean retention scores of 43.22 with a standard deviation of 8.21 and a delayed posttest mean retention scores of 44.22 with a standard deviation of 8.92. The mean gain retention scores of female students exposed to CM was 0.82. This result, therefore, suggests that male students exposed to CM had slightly higher retention than their female counterparts exposed to CM.

Hypothesis 1: There is no significant difference between the mean retention scores of students who were taught geometry using GISP and those taught using CM.

Table 3
Summary of two-way ANCOVA of retention scores of students taught geometry using GISP and Conventional Method.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	38829.333[a]	4	9707.333	289.251	.000	.831
Intercept	1484.382	1	1484.382	44.230	.000	.158
Posttest	9430.952	1	9430.952	281.015	.000	.545
Method	2088.516	1	2088.516	62.232	.000	.209
Gender	23.736	1	23.736	.707	.401	.003
Method * Gender	5.321	1	5.321	.159	.691	.001
Error	7886.663	235	33.560			
Total	777233.000	240				
Corrected Total	46715.996	239				

a. R Squared = .831 (Adjusted R Squared = .828)

The result in Table 3 shows that there is a significant main effect of GISP on students' retention scores in geometry; F(1, 235) =62.232, P < 0.0005, with an effect size of 0.21 (partial eta squared = 0 .209). The null hypothesis was therefore rejected. There is, therefore, significant difference between the mean retention scores of students who were taught geometry using GISP and those taught using CM. The result shows that students who were taught geometry using GISP retained more what they learnt than those taught using CM.

Hypothesis 2: There is no significant difference in the mean retention scores of male and female students who were taught geometry.

Hypothesis 2 was tested with ANCOVA and the result of the test is summarized in Table 3. Table 3 reveals that there is no significant effect of gender on students' retention scores in geometry; F(1, 235) = 0 .707, P = 0.401. The null hypothesis was not rejected indicating that there is no significant difference in the mean retention scores of male and female students in geometry.

Hypothesis 3: There is no significant interaction effect of teaching method and gender on mean retention scores of students who were taught geometry.

Hypothesis 3 was tested with ANCOVA and the result of the test is summarized in Table 3. Table 3 shows a non-significant interaction effect of method and gender on students' mean retention scores in geometry; F(1, 235) = 0.159, P = 0.691. The null hypothesis was not rejected. Therefore, the interaction effect of method and gender on students mean retention scores in geometry is not significant.

Discussion

The findings show that the students who were exposed to GISP had higher mean retention scores than their counterparts exposed to CM. Similarly, ANCOVA of the retention test scores presented in Table 3 indicates that there is a significant difference between the mean retention scores of students who were taught geometry using GISP and those taught using CM. This indicates that the GISP has a positive effect on students' retention of learning in geometry. This finding suggests that the use of GISP in teaching geometry is more effective in retention of learning in geometry than when taught using CM.

This finding may be attributed to the fact that students remember more of what they learnt when the instructional strategy appeals to more than one of their senses, addresses real world issues and relates to their personal experiences. The GISP, appeals to the students' sense of sight (pictorial) in conjunction with the teacher's verbal words which impact on their sense of

hearing. Thereafter, students used the cognitive process called integrating to join the verbal words(narration) with the pictorial(text and animation) and prior knowledge from long-term memory, which perhaps went a long way to improve their retention of learning as stated by Mayer(2001). This is also in line with the cognitive theory of multimedia learning propounded by Mayer and theory of hierarchy of learning propounded by Gagne. This finding is in consonance with the findings of Alhassan et al, (2013),Gambari et al, (2014), Olojede et al, (2017) who reported in their respective studies that using instructional software package in the teaching mathematics improved the retention ability of students more than conventional method.

On the retention of male and female students in geometry, the finding showed that male students who were exposed to GISP had higher mean retention score than female students who were exposed to GISP. Similarly, the male students who were exposed to CM had higher mean retention score than female students who were exposed to CM. This was further subjected to hypothesis testing. The result in Table 10 shows that there is no significant difference between mean retention scores of male and female students in geometry. In other words, the influence of gender on mean retention scores of students in geometry is not significant. This means that retention of geometry concepts does not depend on being male or female. This finding complements the findings of Ramatu et al, (2015) and Obi, Agwagah and Agah (2014)who reported that there was no significant difference in the mean retention score of male and female students taught mathematics. However, this finding is not in agreement with the finding of Egbunu et al, (2017) who reported that there was a significant difference in the retention scores of male and female students and the difference was in favour of male students. The contradiction in findings notwithstanding, the finding of the present study has shown that the influence of gender on mean retention scores of students in geometry is not significant.

The result of hypothesis 3 shows that there is no significant interaction effect of method and gender on mean retention scores of students in geometry. This finding is in consonant with the findings of Giginna (2013) and Nwaodo (2016) who reported also in their respective studies that interaction effect of method and gender on mean retention scores of students was not significant. The finding on interaction effect, therefore, implies that the interaction between method and gender does not influence the mean retention scores of students in geometry.

Conclusion

Based on the findings, the study concluded thus; GISP is more effective in increasing students' retention in geometry. Gender does not influence retention scores of students in geometry. The interaction effect of method and gender on retention scores of students in geometry is not significant.

Recommendations

From the findings of this study, the following recommendations are made: 1. Mathematics and science teachers should be trained on how to develop and use Instructional Software package for teaching and learning in secondary schools. 2. The curriculum should be restructured by NERDC to reflect the basic concept of instructional software packages as they pertain to science and Mathematics teaching/learning. 3. Provision of computers by government agencies and charity organizations should be encouraged for effective utilization in teaching/learning of geometry at the secondary schools.

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