Development and Validation of Geo-TAN Instructional Software Package for Teaching Geometry in Senior Secondary School

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Abstract

Students have consistently showed significant weakness in geometry. Majority of the candidates in the senior secondary school examination avoid questions drawn from geometry, specifically questions based on chord properties, circle theorems and tangent to a circle. Teaching of Mathematics in secondary schools in Nigeria is mostly done using conventional expository method which has been identified as a major cause of students' poor performance in Mathematics especially in geometry. In this 21st century, teaching and learning of many topics in Mathematics require the use of computer and this entails that relevant instructional software packages that teach specific lessons especially the difficult and abstract concepts such as geometry should be developed. In this study GeoTAN Instructional Software Package (GISP) was developed, validated for teaching geometry in secondary schools in Nigeria. GISP was developed for use in the following application software namely; Cinema 4D, Macromedia Flash 8, Macromedia Fireworks 8, Microsoft Word and Adobe Audition. The software development models that were adopted in the development of GISP are Gerlach and Ely; and ADDIE models. A three-stage validation process was used in validating GISP. Educational Software Package Rating Scale (ESPRS) was used by seven Mathematics educators for content validation of GISP. Kendall's Coefficient of Concordance was used to analyse the rating scores in order to determine the agreement or concordance among the raters and reliability of the GISP. The result revealed Kendall's W of 0.82 which indicated that there is agreement among Mathematics educators that the subject matter contents of the developed GISP sufficiently covered the required areas of geometry in senior secondary school two (SS2) Mathematics curriculum. The result showed also that Mathematics educators rated GISP independently and it is reliable for instructional purposes. From the findings of this study, it was recommended among others that GISP should be used by Mathematics teachers in teaching geometry concepts to SS 2 students.

Keywords: Development, GeoTAN instructional software, Geometry

Introduction

Science education is the platform that conveys scientific and technological information and knowledge to the recipients. In science education, Mathematics occupies central and invaluable place such that other science subjects namely Chemistry, Physics, Biology, Agricultural science including social science subject like economics cannot be effectively understood without recourse to Mathematics. Mathematics is a discipline that trains the human mind to understand the world by symbolically and systematically performing reasoning and computation on abstract structures (Joshua, 2016). The importance of Mathematics to human life was succinctly captured by Akinsola and Popoola in Akor (2015) who stated that Mathematics fosters intellectual skills needed to analyse complex problems; recognizes logical relations between interdependent factors as well as formulates general laws on their interrelationship in achieving precision in expression.

Sequel to the foregoing, predicated upon the invaluable role of Mathematics, Federal Republic of Nigeria (FRN, 2013) in the National Policy on Education was apparently motivated to list Mathematics as one of the core and compulsory subjects to be offered by all secondary school students in Nigeria. This implies that all secondary school students in Nigeria must study Mathematics from junior secondary school one to senior secondary school three. Hence, every student is required to obtain at least a credit pass in Mathematics before such student is admitted into higher institution in Nigeria.

The obvious importance of Mathematics notwithstanding, the achievement of secondary school students in Mathematics in public examinations is poor and appalling. The evidence of the poor achievement in Mathematics is predicated on the annual reports of West African Examination Council (WAEC) between 2010 and 2018 which indicated a discouraging performance of students in the subject. The analysis of the performance of students in May/June

West African Senior School Certificate Examination (WASSCE) in Nigeria (WAEC, 2010-2018) shows that the percentage of students who passed at credit level and above (A1–C6) was less than 50% over a period of nine years with the exception of the year 2016 and 2017 where performance was a little above 50%. In a similar development, Fabiyi, (2017) reported that chord property, circle theorem and tangent to a circle were among the concepts in geometry students perceived difficult to learn.

Geometry is one of the five themes in senior secondary school Mathematics curriculum (Nigerian Educational Research & Development Council (NERDC), 2007). Ntshengedzeni (2015) defined geometry as the branch of Mathematics that is concerned with the study of properties, relations of point, lines, surface, solid shape, relative arrangement of the parts, position of objects, movement of objects and the space around the objects which improve learners' spatial imagination. Geometry enhances logical and deductive reasoning for modelling abstract problems and is widely applied in various areas of life such as Computer Aided Design (CAD), modelling, robotics, medical imaging, computer animation and visual presentation (Jacob, Decl, Bolaji, Kajuru & Musa, 2017). Irrespective of the usefulness of geometry to human, the achievement of students in geometry particularly chord properties, circle theorems and tangent to a circle is very poor. This assertion is predicated on the report of WAEC Chief Examiners which revealed that candidates have consistently showed significant weakness in geometry and majority of the candidates avoid questions drawn from chord properties, circle theorems and tangent to a circle (WAEC Chief Examiners' report, 2010; 2011; 2013 - 2018).

This poor achievement in geometry has been blamed on a number of factors. Notable among them is the problem of teaching method which is basically the conventional lecture method. Nworgu (2017) described conventional lecture method as that characterized by

verbalization, memorization, non-interactive, and teacher dominance. This method, however, allows for a wider coverage of content within a short period of time and enables the teaching of large number of students at the same time (Osufor & Njoku 2016). More so, more than 70 percent of science and Mathematics teachers in Nigeria is conversant with conventional lecture method since it suits their traditional pedagogic worldview. Another reason is that conventional lecture method easily interfaces with the Nigerian educational curriculum which is basically theory inclined. Notwithstanding its merits, its demerits outweigh them as it does not promote insightful learning, increase in interest and long-term retention of some concepts (Ahmed & Abimbola, 2011).

In view of the importance of geometry, paying much attention to the methods cum strategies used in its teaching and learning in secondary schools becomes inevitable and desirable. This was**,** therefore, why NERDC (2007) succinctly stated in senior secondary education curriculum in Mathematics that the computerized nature of the global world has led to the intensification of the use of computer in teaching many of the topics in Mathematics. Hence, a lot of Computer Assisted Instruction (CAI) materials are recommended for the teaching and learning of various topics. The Association for Educational Communications and Technology (AECT) (2015) defined CAI as an instructional programme in which the computer is used to instruct the student and where the computer contains the instruction which is designed to teach, guide and test the students until a desired level of proficiency is attained. To this end, the use of CAI **in teaching and learning of Mathematics implies that relevant instructional software packages that teach specific lessons especially the difficult and abstract concepts such as geometry should be developed i**nstructional software package is a combination of one or more files that necessitate the execution of a computer program for the purpose of communicating learning activities, skills and knowledge that are narrowed down to specific

content areas to the learners in an interactive manner (Akukwe & Njoku, 2014). According to Okorie (2015), instructional software package engages learners through the screen instructions from the computer and makes provision for appropriate responses through the attached keyboards; restructures learning environment and makes provision for individual differences of the learners. The point being stressed here is that the instructional software package has the capacity to drill each student and at the same time allows each student to work privately and at the individual student pace. Therefore, adopting teaching approach that is student-centred becomes imperative hence, the development of GeoTAN Instructional Software Package (GISP).

Etymologically, GeoTAN is derived from four words, namely; Geometry, Text, Animation and Narration. GeoTAN Instructional Software Package(GISP) is an instructional software that can be used to teach geometric concepts specifically **chord properties, circle theorems and tangent to a circle** using text, animation and narration simultaneously to the learners **in such a way that it will help** *learners* **build mental representations and construct knowledge by themselves.** In other words, GISP is an instructional software package **that runs on computer system which can be used to teach chord properties, circle theorems and tangent to a circle in an interactive manner which** can help a learner to see the learning experience as text on the computer screen, hears it as it is described in words (narration) and sees the animation that shows illustration of how angles are formed and the position of angles in the diagram. GISP has the capacity to drill each student and at the same time and allows each student to work independently. Furthermore, GISP helps students to access the worked example as a guide to solve some practice questions. It has also a virtual assistant that encourages students with motivational expressions when they pass or fail any practice question.

GISP is in line with the modern teaching approach which involves the use of various activities that make room for the active participation of learners to enhance meaningful understanding of the lesson (Nworgu, 2017). Therefore, GISP **is a student-centred approach that** allows the active participation of learners by **presenting instructional activities in stages and in an interactive manner to students.** In each lesson, the stages of presentation involve introduction, list of lessons, specific objectives of each lesson, test on previous knowledge, explanation of the learning activities both in text, narration(voicing) and animation; students' activities for evaluation and summary of the lesson. GISP has interactive features in that it shows the leaner whether the option selected is right or wrong. It also allows every student to navigate from one link to another using Home, Next, Back and Exit buttons. Against this background, GISP was developed and validated for teaching geometry in secondary schools. The problem of this study was: would the developed and validated GISP sufficiently cover the required area of geometry based on SS2 Mathematics curriculum?

Purpose of the Study

The purpose of the study was to develop and validate GeoTAN Instructional Software Package (GISP) for the teaching and learning of geometry by senior secondary school students using the following topics in geometry namely, chord property, circle theorem and tangent to a circle. Specifically, this study sought to find out if the developed GISP sufficiently and appropriately covered the chosen content of geometry.

Research Questions

The research question that guided the conduct of the study is; what are the mean ratings of Mathematics educators on GISP content?

Hypotheses

The hypothesis tested at 0.05 levels of significance is; there is no significant difference in the mean ratings of Mathematics educators on the content of GISP.

Method

The research design adopted in this study is instrumentation. Ali (2006) defined instrumentation design as that which is geared towards the development and validation of measurement instrument or the investigation and introduction of new techniques for use in educational practice. The International Centre for Educational Evaluation in Okorie (2014) defined instrumentation design as one which aimed at the development of new or modification of content, procedure, technology or instrument of educational practice. Going by these definitions therefore, instrumentation design is said to be the development of measurement instrument or new technologically based technique such as instructional software and strategies for use in educational practice. The purpose of the present study fits into the definition of instrumentation design. Hence, its adoption in this study is because GISP was developed and validated by the researchers.

Developmental Procedure of GISP

Requirement specification: This involves defining in specific terms what was to be learned. In the case of this study, it was Mathematics and specifically topics in geometry namely, chord property, circle theorem and tangent to a circle.

Design: This has to do with the process of specifying how geometry is to be learned. The Lesson Plan on Geometry (LPG) in this study was designed by the instructional designer – the researcher. Afterwards, LPG was used in the preparation of developmental plan of GISP.

Coding: At this stage, the content of the developmental plan was coded into the computer with the use of the following application software namely; Cinema 4D, Macromedia Flash 8,

Macromedia Fireworks 8, Microsoft Word and Adobe Audition**.** Cinema 4D was used to create the 3-dimentional images. Macromedia Fireworks 8 was used to create 2-dimentional images. This is because it allows very tiny file size compared to other graphic application software. Macromedia Flash 8 enabled the assemblage and embedment of graphics, text, interactive features and audio in the software. In fact, Macromedia Flash 8 was used as the overall platform. Microsoft Word was used for formatting the text. Lastly, the a**dobe audition was used for recording voice over.** The GISP development was perfected through the assistance of professional computer programmer.

Integration: This entails creation of slides, addition of animation effects and narration to the slides in the instruction. The following four steps were taken:

Step 1: Transition: the movement of the slides in the instruction was controlled using next and backward button.

Step 2: Animation: this was used to create 2-dimensional and 3-dimensional images used for examples and illustrations in the instruction.

Step 3: Adding voice or narration to the slides in the instruction.

Step 4: Saving the instruction into a storage medium

Software development model: The software development models that were adopted in the development of GISP are Gerlach and Ely; and ADDIE models for instructional software package.

Software development technique: Software development technique that was employed was the combination of Tutorial, and Drill and Practice.

Usage: The following mode and technique were adopted in the usage:

Mode of Environment: The mode of environment employed was hybrid environment. Hybrid environment is a learning environment where the students received instruction both from the

teacher and computer. In other words, it involves guiding the students and making necessary explanation to the students as they learn geometry using the GISP.

Implementation Technique: The implementation technique was synchronous implementation which involves a situation where all students in a particular location are exposed to the same learning experiences and materials at the same time. That is, GISP was installed in the computer systems in computer laboratories such that all the students were exposed to the same learning experiences and materials at the same time.

Test Instrument Used for Evaluation in GISP

The instrument used for evaluation in GISP was researchers-adopted Geometry Achievement Test. It consists of 70 multiple choice objective items adopted from past question papers of West African Examination Council (WAEC, May/June, 1988-2018, Nov/Dec, 2010-2017, Jan/Feb, 2018). Two questions were used to test previous knowledge of students in each lesson while five questions were used for evaluation in each lesson. The items were validated by Mathematics teachers and; measurement and evaluation experts. It was tested for reliability using 30 randomly selected SS3 students. A reliability coefficient of 0.87 was obtained using the Kudar Richardson (KR-20) which was considered reliable for the research study.

Validation of Instrument

The Educational Software Package Rating Scale (ESPRS) adapted from Educational Software Evaluation Consortium (Bitter & Wighton, 1987) was used to validate GISP. It contains 14 item evaluation criteria. The criteria are correctness of presentation; content presentation; integration into classroom use; ease of use and curriculum congruence. Others are user control program; teacher documentation; colour, sound, graphic, and animation features; reliability; and content bias. It is structured on a 4-point rating scale of Excellent, Good, Fair and Poor. The 4-point rating scale of the items were assigned numerical values of

4,3,2 and 1 respectively. The ESPRS was validated by two professional secondary school Mathematics teachers and three Mathematics educators. After the validation, the reliability coefficient of ESPRS was established. To establish the reliability coefficient of ESPRS, the instrument was giving to 20 specialists (eight Mathematics educators, seven computer experts and five educational technologists) for rating. Cronbach Alpha reliability coefficient was thereafter used in analysing the rating scores in order to determine the internal consistency coefficient of the ESPRS. The internal consistency reliability coefficient of 0.85 was obtained after the computation. The instrument was therefore judged reliable.

The Validation of the GISP

In validation of GISP, two types of validation were used – the face and content validations. This was done in three stages namely expert validation comprising of educational technologists and computer programmers; content validation comprising of Mathematics specialists and field validation comprising of SS2 students.

Stage one: Expert validation

The GISP was face validated by three computer programmers and three educational technologists. First, the three computer programmers were given the research title, purpose of the study and GISP. The researchers requested them to assess the GISP in terms of the following: language, legibility, durability, animations, interactivity, interface, navigation, voice over and packaging. Their suggestions were used to modify the package. Second, three educational technologists were given the research title, purpose of the study and GISP. The researchers requested them to determine the appropriateness of GISP in terms of suitability for instruction, emphasis on key concepts, use of examples and illustrations, moving from known to unknown, unity of colour, animation, text and voice, curriculum congruence, and lesson evaluation, thereafter, their corrections were used to improve GISP.

Stage two: Content validation

The content validation was done in two stages. In the first stage, the developmental plan of GISP written by the researchers was given to Mathematics specialists for validation. They were given the lesson blueprint, scheme of work and senior secondary school Mathematics curriculum, the research title and purpose of the study; and requested them to validate the developmental plan of GISP in terms of finding out if the content of the developmental plan of GISP adequately and sufficiently covered the Nigerian secondary school Mathematics curriculum. Thereafter, the comments of the specialists were used to correct some mistakes whereas their suggestions were used to improve the developmental plan of GISP. The second stage of content validation came after the development of GISP. The developed GISP was given to five Mathematics educators and two instructional software package designers (who are also mathematics educators) for validation. The Mathematics educators were given the research title, purpose of the study and ESPRS. They were requested to carry out the content validation of the GISP by ensuring that it was in line with the 14 criteria in ESPRS. Their comments were the rating scores in the ESPRS. The Kendall's Coefficient of Concordance was used to analyse the rating scores in order to determine the agreement or concordance among the raters and reliability of the GISP.

Stage three: Field validation

Afterwards, a pilot study was carried out with GISP. For this reason, GISP was administered to 20 SS2 students. In the school selected for the pilot study, the research assistants (regular Mathematics teachers) helped the researchers to ensure that the computers were in good working condition. Projectors were properly set and computers booted by researchers. During the first 40-minute lesson, students were given a short introduction on how to use GISP. That is familiarizing the students with GISP. The researchers directed students to boot their own computers systems. After that, researchers inserted the CD in the CD drive and

students also inserted CD in the CD drive. Teachers guided the students to perform the following functions in computer systems:

1. Click to open the folder to view the file.
2. Select the GISP and click open with Macromedia Flash 8 to open the lessons.
3. Select lesson one and click to open it
4. Listen to the narrative instructions and follow it.
5. Attempt the questions drawn from previous knowledge. The package is designed in such a way that the learner can go to the next step even if the correct answer is not gotten.
6. Thereafter, click the Next button to get to the next step and listen to the narration
7. Continue clicking Next button to read and listen to narration until they get to evaluation.
8. Attempt the question for evaluation and listen to the narration.
9. Clicking Next button to go to summary of the lesson
10. Interact with the computer and learning material while the researchers watched and intervened where and when necessary.
11. Click to close the file.
12. Remove the CD from the CD drive and keep CD safe for other lesson during the next mathematics period.
13. Finally, shut down the computer.
    Thereafter, their observations were used to improve GISP.

Results

Table1: Mean ranks of Mathematics educators

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mean Ranks	9.4	9.4	8.4	8.4	9.4	9.4	9.4	8.4	9.4	8.4	8.4	2.4	2.4	2.4

Data on Table 1 show that items of the instrument had mean ranks 9.4, 9.4, 8.4, 8.4, 9.4, 9.4, 9.4, 8.4, 9.4, 8.4, 8.4, 2.4, 2.4, and 2.4 respectively.

Table 2: Summary of Kendall's W Test Statistics on Rating of Mathematics Educators of GISP

N	Kendall's W[a]	Chi-Square	df	Asymp. Sig.
7	0.817	74.315	13	.0005

a. Kendall's Coefficient of Concordance

The result in Table 2 shows that Kendall's Coefficient of Concordance is 0.817. The coefficient of 0.817 implies that Mathematics educators had a high agreement. The null hypothesis was therefore rejected showing that there is significant agreement among Mathematics educators on the content of GISP. Hence, GISP sufficiently and appropriately covered the chosen content of geometry.

Discussion

The finding revealed that there is agreement among Mathematics educators that the contents of the developed GISP sufficiently covered the required areas of geometry based on senior secondary school (SS2) Mathematics curriculum. The result shows also that Mathematics educators rated GISP independently. It therefore means that GISP is reliable for instructional purposes. The reason could be that the procedure adopted in the development of GISP met the required standard of developing instructional software package. The finding of this study agrees with the finding of Isiaka and Mudasiru (2014) that developed and validated computer instructional package for learning Physics which produced a very good performance when used for Physics instruction. The finding of this study is also in consonance with the finding of Okorie (2014) who developed and validated the CBISP in Chemistry. The finding of this study further agrees with the finding of Usman, Wishishi, Gambari, and Olayinka (2017) who developed and validated instructional software package *in Hausa Language forteaching and learning of geometry at junior secondary school level.*

Conclusion

In this study, it was concluded that the contents of the developed GISP sufficiently covered the required areas of geometry in appropriate and sequential manner.

Recommendations

From the findings of this study, the following recommendations are made:

1. The use of GISP should be used by Mathematics teachers in teaching geometry concepts to students.
2. Computers should be provided by government agencies such as State Governments, and Federal Ministry of Education for effective utilization in teaching/learning at the secondary schools.
3. Mathematics teachers should be made to become computer literate so that they can develop appropriate instructional software package.
4. The development and validation procedures adopted in this study could be used as a model on development and validation of instructional software packages by teacher training institutions for training and retraining teachers.

References

Akor, A.E. P (2015). *Effect of achievement motivational instructional approach on primary six pupils' numerical aptitude and retention in Mathematics* (Unpublished doctoral dissertation) University of Nigeria, Nsukka.

Akukwe A. C.& Njoku, J.I (2014*). Introduction to computer studies.* Owerri: Onii Publishing House.

Association for Educational Communications and Technology (AECT, 2015). *Educational technology definition and glossary of terms.* Washington, DC: Association for Educational Communications and Technology.

Fabiyi, T.R. (2017). Geometry concepts in Mathematics perceived difficult to learn by senior secondary school students in Ekiti State. *IOSR Journal of Research & Method in Education (IOSR-JRME), 7* (1), 83-90.

Federal Republic of Nigeria (2013). *National policy on education* (5th Ed.). Lagos: NERDC Press.

Isiaka, A. G. & Mudasiru O. Y (2014). The development and validation of computer instructional package on physics for secondary schools in Nigeria. *Educational Research International,3*(1) 112-130.

Jacob, T. A, Decl, C. Bolaji, Y. K., Kajuru, M. M, & Musa, K. B. (2017). Effect of concrete manipulative approach on attitude, retention and performance in geometry among junior secondary school students in Benue State. *IOSR Journal of Research & Method in Education*,*7*(6), 80-175.

Joshua, M.T (2016). *Communication technologies and Science, Technology, Engineering and Mathematics (STEM) education*. Keynote address presented at the 57th annual national conference of Science Teachers Association of Nigeria from 15th-20th August, Government College, Ado Ekiti.

Nigerian Educational Research and Development Council, (NERDC, 2007). *New senior secondary education structure at a glance*. Lagos: NERDC Press.

Ntshengedzeni, R. M. (2015). *Enhancement of learners' performance in geometry at secondary schools in Vhembe District of Limpopo Province*. (Unpublished doctoral dissertation), University of Venda, Venda.

Nworgu, B. G. (2017). *Modern teaching approach*. Paper presented at the one day stakeholders' forum on e-curriculum. Nigerian Educational Research & Development Council (NERDC). Retrieved from https://www.facebook.com/NERDC

Okorie, E. U. (2014). Development and validation of teacher-made instructional software package for teaching chemical bonding in secondary schools. *Journal of Education and Practice*. 5 (22), 28 – 33.

Okorie, E. U. (2015). Effects of instructional software package method of teaching on students' interest and achievement in chemical bonding. *Scientific & Academic Publishing*; 5(6): 158-165.

Usman, B. A., Wishishi, D. I., Gambari, A. I. & Olayinka, O. (2017). Effect of developed web-based instructional package in Hausa language on academic achievement of upper basic students in geometry in Niger State. *ATBU, Journal of Science, Technology & Education (JOTE)*, 5(2), 109-118.

Vanguard, Newspapers (November 21, 2018). *Waec-releases-2018- wassce-results for private candidates recording 60% failure/*. Retrieve from https://www.vanguardngr.com

West African Examination Council (WAEC) (2008 – 2018). *Chief Examiners' Reports.* Yaba: Lagos State.