Effect of GeoGebra Package on Learning Outcomes of Mathematics (Secondary School) Students in Ogbomoso North Local Government Area of Oyo State

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Abstract: This study examined the effect of GeoGebra software on the performance of learners in Mathematics. It also assessed the effect of gender on the performance of learners taught Mathematics with the use of GeoGebra package, and further investigated the effect of the Information and Communication Technology (ICT) package on students' attitude towards Mathematics in the area. These were with a view to provide empirical information on the effectiveness of the package in improving students' learning outcomes in Mathematics as well as to provide a template for integrating ICT into Mathematics class instruction in particular and teachers' education/training programme in general.

The study adopted the non-equivalent pre-test post-test control group design. The study population comprised secondary school Mathematics students in Ogbomoso North Local Government Area of Oyo State. The senior secondary school two (SS II) Mathematics students from two intact classes from each of the two purposively selected schools in the area constituted the sample (54 students for experimental group and 51 students for control group). Availability of functional computer systems served as basis for selecting the schools. The classes were assigned into two groups (experimental and control) using simple random sampling technique. The experimental group was taught using GeoGebra, while the control group was taught using the conventional method. In experimental group, the students interacted with different kinds of GeoGebra tools to solve problems in geometry, algebra, introductory calculus, among others. The control group was exposed to the conventional method and taught the same topics. The experiment lasted for the period of six weeks. Two instruments were used for data collection, namely: Student Achievement Test in Mathematics (SATM) and Mathematics Attitudinal Scale (MAS). The two groups were pre- and post-tested using SATM, after which MAS was also administered to them. Data collected were analyzed using t- test statistics.

The findings showed that the students taught with GeoGebra performed better at the post-test level than the pre-test level in Student Achievement Test in Mathematics, t_{cal} at 0.05 probability level was 2.04 while the critical value,t_{tab} was 1.98 ($t_{cal}>t_{tab}$). However, the result showed that there was no significant difference in the sampled students' performance based on gender, since t_{cal} was 0.66 while the critical value,t_{tab} was 2.01($t_{cal}<t_{tab}$). The result further showed that the attitude of students towards Mathematics is significantly dependent on their knowledge of GeoGebra, since t_{cal} 2.12 is greater than t_{tab}1.98 (2.12 > 1.98). Hence, the knowledge of GeoGebra positively influenced the attitude of students towards Mathematics

It was therefore concluded that the integration of GeoGebra, an ICT package, would have positive effect on the students' learning outcomes in Mathematics, especially on students' performance in both internal and external examinations, and at the same time, their attitude towards Mathematics would be greatly enhanced.

Statement of the Problem

In recent times, the teaching and learning of Mathematics in secondary schools in Nigeria has witnessed a great setback with students, irrespective of sex, performing

poorly and showing lack of interest. This is evident in the performance of the students in Basic Education Certificate and Senior Secondary Certificate Examinations. Mathematics is a very important subject, yet it is a subject that many students fear, fail and possibly dislike. The problems have been attributed partly to lack of instructional materials especially the modern educational facilities like Information and Communication Technology (ICT). Other problems include little or no motivation for teachers and students, and overcrowded classes. The aforementioned could be adversely affecting the teaching and learning of Mathematics in Nigerian secondary schools. GeoGebra, an ICT Mathematics software package for teaching Geometry, Algebra and Calculus has been developed by Markus Hohenwarter in response to this lack, but its effect on students' learning outcomes such as performance and attitude to Mathematics has not been established in Nigeria; hence this study.

Purpose of the Study

The purpose of this study is to investigate the effect of GeoGebra software ICT package on learning outcomes of Mathematics students in Ogbomoso North Local Government Area of Oyo State.Hence, the specific objectives of this study are to:

(a) examine the effect of GeoGebra on the performance of learners in Mathematics in Ogbomoso North Local Government Area of Oyo State;

(b) assess the effect of gender on the performance of learners taught Mathematics withthe use ofGeoGebra in the study area;

(c) investigate the effect of GeoGebra on students' attitude towards Mathematics in the area.

Research Hypotheses

The following hypotheses were formulated for the study at 0.05 probability levels:

H_{01} There is no significant difference between the pre-test and post-test performance of students taught Mathematics with the use of GeoGebra software.

H_{02} There is no significant difference between the post-test performance of male and female learners taught Mathematics with the use of GeoGebra software.

H_{03} The attitude of students towards Mathematics is not significantly dependent on their knowledge of GeoGebra.

Significance of the Study

The study is expected to provide empirical information on the effectiveness of GeoGebra in improving the students' learning outcomes in Mathematics. Results of this study will also provide a template for integrating ICT into Mathematics class instruction. Findings from this study will serve as eye opener to the Mathematics teachers of the use of GeoGebra software in the teaching and learning of Mathematics in secondary schools. The package can also be integrated into the teachers' education/training programme.

The package would subdue the age long fears of students in the study of Mathematics and thereby lead to the improvement of students' performance and subsequently enhance their further learning of Mathematics in higher level. The knowledge of the package tagged GeoGebra would also enhance students' attitude towards the subject.

Theoretical Framework

This work is hinged on the Learning by Discovery Theory of Bruner (1961). Brunner and his colleagues worked at the centre of cognitive study at Harvard University. They studied children between 4 – 11 years of age. "Bruner, like Piaget, is a developmental theorist whose work is mainly concerned with the way children learn" (Oloyede, 2007). The improvement of the quality of mathematical thinking of learners was his most essential concern. He suggested that children mental functioning and learning progress pass through quantitatively different stages. According to him, one can get to know something by doing it, seeing it or imagining it. In this manner, a student can learn concepts of Mathematics through the interaction with GeoGebra software package. These are related to the three stages of development (levels of processing information) posited by him, they are:

i. The Enactive (Motor Level)
ii, The Iconic (Perceptions And Images)
iii. The Symbolic (Abstract Ideas)

Enactive stage indicates adaptation at the motor level shown by a capacity in the child to move around, to reach and to grasp, among others; the learner acts on the objects in order to learn. He thereby touches and manipulates them. At ***Iconic stage,*** the learner is able to represent the world to himself through image. He forms the images in concrete terms. The learner at this stage learns in terms of seeing and picturing in mind. ***Symbolic stage*** allows a child to develop more general and mathematical abstract ideas which can be expressed in words or numbers. The learner, at this stage, is able to use language, logic and mathematical symbols in order to describe and discuss what he has learned.

According to Oloyede (2007), Bruner asserted that any subject matter can be taught effectively to any learner at any stage of development. This indicates the difference between the Bruner's theory and that of Piaget. The process of learning is more important than the product according to Bruner. With the use of GeoGebra software package, the role of the teacher changes from that of a lecturer who cares less for his learners, to that of a resourceful person who cares most for his students.

Bruner (1961) said that knowing is a process and so his work focused on the importance of understanding the structure of a subject being studied, the need for active learning as the basis for understanding, and the importance of reasoning in learning. When learners are presented with perplexing situations they will want to figure out a solution; an interactive software package like that of GeoGebra can be of help in such a situation. This belief was the basis for creating discovery learning activities. With GeoGebra package, the teacher's work is only to guide since the students can freely create their modern facilities for learning Mathematics.

Bruner's connection with the National Science Foundation curriculum development projects of the 1960s was instrumental in formulating discovery approaches to science and Mathematics learning. The goal of education should be intellectual development and that the Mathematics curriculum should foster the development of problem-solving skills through inquiry and discovery of which GeoGebra was design to take care of.

The package encourages students to actively use their intuition, imagination, and creativity. This discovery learning approach uses inductive reasoning by starting with the specific and moving to the general. For example, the teacher presents examples and the students work with the examples until they discover the interrelationships. The package

was designed in support of Bruner's submission that classroom learning should take place through inductive reasoning by using specific examples to formulate a general principle.

Bruner (1961) suggested that teachers can nurture inductive thinking by encouraging students to make guesses based on incomplete evidence and then to confirm or disprove the guesses systematically. To apply his ideas in the classroom, teachers would create his own modern instructional materials and then instruct the learners to create their own.

Duyilemi (2009) highlighted the implications of Bruner's theory to teaching, they are:

i. Mathematics can be taught usefully and honestly to any child at any stage/level. To take care of this, GeoGebra was designed for all levels of education.
ii. He advocates self discovery as a means of reward for the child rather than external rewards which may lead a child towards teacher prescribed goals. GeoGebra is usher friendly package which enables the student to discover mathematical concepts with ease.
iii. He believes that what is crucial in learning is not storage of knowledge but retrieval (recall). GeoGebra package is interactively structured and related to the environment.
iv. The package leads to problem-solving and reflective thinking approach to teaching and learning of Mathematics.

Scope and Limitation of the Study

This research is limited in scope and coverage to Ogbomoso North Local Government Area of Oyo State. The researcher would have loved to make the study a broad one in scope and coverage but due to time constraint on the part of the researcher, he has limited himself to only two randomly selected schools in the Local Government.

Also, this research only examined the effect of GeoGebra software on learning outcomes of Mathematics students at senior secondary school level.

Operational Definition of Terms

(a) **Attitude**: This is the disposition that a student has about Mathematics before and after the introduction of GeoGebra software to the class. It indicates the students' disposition or feeling towards Mathematics.

(b) **Performance**: These are the scores derived from Student Achievement Test in Mathematics.

(c) **Learning Outcomes**: These are determined by the students' performance and attitude towards Mathematics.

(d) **Technology**: This is the application of scientific knowledge to provide solutions to human problems. In most cases it is referred to as Information and Communication Technology (ICT).

(e) **GeoGebra**: GeoGebra is an interactive dynamic Mathematics software on geometry, algebra, statistics and calculus application, designed for teaching and learning of Mathematics from primary school to university level.

Discussion of Results

Through the findings of this study, it was discovered that there was no significant difference in the performance of students taught Mathematics with the use of GeoGebra and the students taught Mathematics with conventional method before the treatment. This

implies that both groups had the same mathematical background before the commencement of the treatment. The result of hypothesis one which stated that "There is no significant difference between the pre-test and post-test performance of students taught Mathematics with the use of GeoGebra software" revealed that the students in experimental group gained higher scores in their post-test performance than the pre-test performance. By implication, there was significant difference between the pre-test and post-test performance of students taught Mathematics with the use of GeoGebra software.

Meanwhile, the result of the hypothesis two which stated that "there is no significant difference between the post-test performance of male and female learners taught Mathematics with the use of GeoGebra software" indicated that there was indeed no significant difference between the mean performance of male and female learners taught Mathematics with the use of GeoGebra. This is in line with the submission of Idowu (2012) that there was no significant difference in the students' performance based on gender. However, this is against the findings of Endawoke's (2001) and Leath's (2001) as revealed by Idowu (2012) that males performed better than females in Science and Mathematics.

Based on the result of hypothesis three which stated that "the attitude of students towards Mathematics is not significantly dependent on their knowledge of GeoGebra", it was discovered that the knowledge of GeoGebra positively influenced the attitude of students towards Mathematics. This is agreed with the view of Oyediran (2012) that the attitude of students to science / Mathematics is encouraged when a teacher that is versatile in Information and Communication Technology handled them, and the reverse is the case when the science / Mathematics students are handled by the teacher that is Information and Communication Technology (ICT) phobia. The students' performance in science / Mathematics is always encouraging when taught by the teacher that is well groomed in ICT but always disheartening when taught by the teacher with shallow knowledge in ICT.

Summarily, through the findings of this study, it was discovered that majority of students exposed to GeoGebra, irrespective of gender, did not only perform well in Mathematics test after the treatment, but they also developed right attitude towards Mathematics, comparing these with their performance and attitude before the treatment.By implication, the integration of ICT as a whole and GeoGebra in particular would in great measure improve the students' learning outcomes in Mathematics, especially on students' performance in both internal and external examinations, and at the same time, their attitude towards Mathematics would be greatly enhanced.

Summary

This study examined the effect of GeoGebra on learning outcomes of Mathematics Secondary School Students in Ogbomoso North Local Government Area of Oyo State. The need to carry out this research arose due to the inconsistent performance recorded by the students especially at the external examinations like Basic Education Certificate Examination (BECE), West African Examination Council (WAEC) and National Examination Council (NECO). There seems to be little or no improvement despite the various recommendations from the past researchers and there was indeed the need to inculcate ICT into the teaching-learning of Mathematics, which GeoGebra takes care of.

The study adopted the non-equivalent pre-test post-test control group design. The study population comprised senior secondary school two (SS II) Mathematics students in

Ogbomoso North Local Government Area of Oyo State. The senior secondary school two (SS II) Mathematics students from two intact classes from each of the two purposively selected schools in the study area constituted the sample. Availability of functional computer systems served as basis for selecting the schools. The classes were randomly assigned into two groups (experimental and control). The experimental group was taught using GeoGebra, while the control group was taught using the conventional method.

In GeoGebra class, the students interacted with different kinds of GeoGebra tools to solve problems in geometry, algebra, introductory calculus, among others. The control group was exposed to the conventional method and taught the same topics. The experiment lasted for the period of six weeks. Two instruments were used for data collection. They are Student Achievement Test in Mathematics (SATM)and Mathematics Attitudinal Scale (MAS), both of which were administered to both groups. The two groups were pre- and post-tested using SATM, after which MAS was also administered to them. Data collected were analyzed using t- test statistics.

Three hypotheses were generated for this study as indicated in chapter one. The results of pre-test were subjected to t- test to determine the initial mathematical background of the students. The result of t- test as displayed in Table 4.1 showed that there was no significant difference between the mean scores of the two groups.

The hypothesis one, as displayed in Table 4.2, was rejected at 0.05 probability level using a t- test statistics. By implication, students taught with GeoGebra performed better in the post-test than the pre-test in Student Achievement Test in Mathematics.

Hypothesis two could not be rejected at 0.05 probability level using a t- test statistics as displayed in Table 4.3. Meaning that, there was no significant difference in the students' post-test performance based on gender.

Subjecting hypothesis three to t- test analysis at 0.05 probability level, it was discovered, as shown in Table 4.4, that the attitude of students towards Mathematics is significantly dependent on their knowledge of GeoGebra.

The researcher therefore observed that, the integration of ICT as a whole and GeoGebra in particular will in great measure improve the students' learning outcomes in Mathematics, especially on students' performance in both internal and external examinations; and at the same time, their attitude towards Mathematics will be greatly enhanced.

Conclusion

This study concluded that students' performance in Mathematics, irrespective of gender, can be greatly enhanced through the incorporation of GeoGebra software into Mathematics classroom instruction. They can also develop right attitude towards Mathematics.

Recommendations

Based on the learning outcomes of the students involved in this study, their responses and the experience gathered in the course of carrying out this research, the following recommendations are put forward in conformity with the findings of this study.

(a) GeoGebra and other ICT packages should be fully integrated into secondary schools and other levels of education.

(b) Since the inculcation of these ICT packages are subject to availability of computer systems, government should encourage the use of computer and other ICT facilities such as PowerPoint and projector for the teaching-learning of

Mathematics.

(c) There should be conferences, seminars, workshops and in service training for the teachers on how to improve in teaching of Mathematics, including the thorough training on how to use this ICT package effectively, since one cannot give what he/she does not have.

(d) The Mathematics teachers should guide the students to form their ICT based instructional materials from GeoGebra, bearing in mind that no topic should be taught in abstract; especially since there won't be extra cost for the teachers. The students will be able to form, create, save, retrieve and print on their own.

(e) Government, Proprietors and School authorities, among others, should try as much as possible to contribute their own quota in providing enough computer systems for students' use.

(f) Government should make computer education a core subject at all levels of education throughout the country and subsidize the procurement of computers and their accessories.

(g) Mathematics laboratory should be established in each level of education.

Suggestions for Further Studies

This study assessed the effect of GeoGebra (an ICT package) on students learning outcomes in Mathematics. From the findings of this study, the following suggestions are thereby forwarded to the future researchers:

(a) Since GeoGebra is a newly developed ICT package for the effective teaching and learning of Mathematics, it is therefore necessary to introduce the package to the Mathematics teachers who will later be in the best position to train the students.

(b) Prolong time could be devoted for this kind of research for the assurance of inculcation and implementation.

(c) The use of GeoGebra has been extended from primary school to tertiary level of education; similar studies could also be carried out in any level of education.

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