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Students' perception and performance across ability levels on GeoGebra software usage in learning of circle geometry

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Abstract
This study investigated Students' Perception and Performance across ability levels on GeoGebra Software usage in Learning of Circle Geometry. The study was guided by two research questions and two null hypotheses which were tested at .05 alpha level. Descriptive and quasi-experimental research design was used. A sample of 64 senior secondary two students was selected from a population of 25,913 from the 33 public schools in Yenagoa Local Government Area of Bayelsa State. The purposive sampling technique was employed to select the sample. The instrument used for the collection of data was Geometry Performance Test (GPT) and Students Perception on GeoGebra Software (SPGS). A reliability index of 0.82 and 0.63 was established for GPT and SPGS using the test-retest Cronbach methods respectively. The mean, standard deviation, t-test and analysis of covariance were used to analyse the data. The result showed that students had a positive perception on the use of GeoGebra software for the teaching and learning of circle geometry and there was no significant difference between the perception of the male and female students on the use of GeoGebra software for the teaching and learning of circle geometry. The result also revealed that students of all ability levels benefitted from the use of GeoGebra software in the teaching and learning of circle geometry. It was concluded that the use of GeoGebra software to teach circle geometry improved students' performance of all ability levels and students have a positive perception of the use of GeoGebra software.

Keywords: GeoGebra, perception, circle geometry, software, ability level

Introduction
Computer Assisted Instruction (CAI) is a self-learning technique, usually offline/online, involving the interaction of the student with programmed instructional materials. An interactive instructional technique whereby a computer is used to present the instructional material and monitor the learning that takes place, (WikiEducator, 2008) [13]. Computer-assisted instruction (CAI) like tutorials, drills, games and simulation provides operations that take the form of questions (simulates) and answers (response) structures that acquaint the students to the subject matter in a unified manner by building their interest in the short term which propels a long-term effect on their academic performance. As students engage with computer tools, they explore for deep understanding with the desire to try and use the acquired knowledge in their future endeavour. Computer instruction allows students to make connections with everyday life experience and also promotes deep learning as students engage and manipulate the impact parameters i.e. altering the values of a system to explore their effects. Computer-assisted instruction encourages one-to-one interaction and motivates students with the freedom to experiment with different options and provide immediate feedback in the learning process. The multimedia feature of computer-assisted instruction helps students to understand difficult concepts through a multi-sensory approach.

Perception is a process by which an individual absorbs sensory information from the environment and utilize such information as a means of interacting with the environment. It is a way individual perceive things around them that defines their character and attitude. How students perceive a particular lesson shapes their goals and reflect on their outlook. Perception on a school subject by a student is a determinant of whether that student is happy or grossly hate that subject and this implies that students formulate their own opinion on which side to swing in terms of taking decision on a particular lesson. Robbins (2005) [9] defined perception as a process by which individuals organise and interpret their sensory impressions in order to give meaning to their environment. He noted that people's behaviour is based on their perception of what reality is, not reality itself and that the world as it is perceived is the world that is behaviourally important. Perception is an entrance activity in learning to continue after reception of stimuli as the processing of information in the central nervous system and then storing in the memory, (Reboji, 2010) [10]. Perception itself depends on one's world view. Ability level also known as academic attainment refers to the characteristic mode of functioning that an individual show in intellectual activities in a highly consistent and persuasive way (Adeyemo, 2010). The ability of a student to engage himself meaningfully in any educational task which requires higher cognitive functioning depends on his academic potential/capability. The academic capability generally dictates the pace at which a student can learn. Adeyemo (2010) identified three ability levels in relation to teaching and learning which includes high, medium, and low. High ability level learners are those that prefer isolation and social distance, theoretical and abstract ideas. This group of learners are apparently better than medium or low ability group and they may not present any immediate concern for teachers, but teachers must ensure that this type of learner does not become complacent. This group of students may become frustrated with their teacher for not providing more challenging lessons and can also be bored while waiting for other students to assimilate. Medium ability level learners perform relatively better on learning activities involving social materials with the progressively harder task to grow their confidence. Low ability level learners are those with less academic capabilities than their peers. This group learn at a slower pace and requires the teacher to pay special attention as they may excel in specific areas. They need extra time to complete activities and are often dependent on peer support to complete a given tax. They are cognizant of the fact that every other person in their class learn better as they do and sometimes become frustrated on their inability to learn efficiently.

GeoGebra is a powerful software for teaching and learning mathematics. It offers geometry, algebra and calculus tools in one environment, and great support indeed for linking mathematical concepts. GeoGebra is known as a dynamic geometry software, as "a computer-based" tool which provides active, experimental and exploratory instruction with the help of symbolic links which offers many opportunities in this respect (Yuksel and Cildir, 2015) [14]. One can easily download the software on (http://www.geogebra.org) and consequently use it in teaching. This, in essence, makes GeoGebra very important to teachers of mathematics as they have the relevant competence in mathematics and provide students with enough support for reaching a good level of performance in competencies related with using tools, managing representations, and problem-solving (Antonio, Albladejo & Garcia, 2015) [3].

The use of dynamic geometry software involves virtual activities that improve conceptual understanding which effects on learning cannot be overemphasized. The effectiveness of computer-based manipulatives is observed in its ability to retract feedback by connecting the concrete and symbolic representations. Computer tools link between pictures, tables, graphs, equations, etc. which enables students to know more facts and methods and afford them to transfer knowledge to new situations and contexts. For example, when students stretch a computer geoboards rectangle and see the measures of the sides, perimeter, and area change with their actions then, this implies that they are involving in a thorough understanding of the underlying and foundational concepts behind the algorithms performed in mathematics (Hope, 2006). The connections, ideas and relationships experienced in the dynamic geometry environment when working on a particular mathematics concept make the application of computer tools an excellent way of building students' conceptual knowledge. Computer use and academic performance study have shown that technology program improves student academic achievement. (Fuchs & Woessmann, 2004) [7], studies about the effectiveness of computer use for instruction had found positive relationships between computer and student's academic achievements. Technology advocates have claimed that the 21st-century information and communication tools (computer-assisted instructional applications) can positively influence students learning processes and outcomes due to its ability to deal with content areas and the development of higher order skills.

Statement of the Problem

Circle geometry is an area of Mathematics that many students shy away from as a result of the technicalities involved in it. Mathematics teachers have been teaching circle geometry using the traditional method without integrating technological gadgets. In this 21st century, every sphere of human endeavour has experienced the use of technology to solve some of the problems it faces when there was no hi-tech. The classroom activities in the educational sector are not ruled out in the hi-tech benefits. Mathematics software has been developed to digitally offer an interactive session or platforms for the teaching and learning of Mathematics concepts and skills. The dearth or lack of computers and software, computer laboratories and low teacher technological knowledge has prevented so many teachers not to get involved in the integration of technological gadgets. GeoGebra is a Mathematics software that can be used to teach and learn Circle, geometry, calculus and statistics. There are schools that are equipped with GeoGebra software and computer laboratories and the teachers have continued to teach students circle geometry using the traditional method. This study, therefore, sought to investigate students' perception and performance across ability levels on the use of GeoGebra software for the teaching and learning of circle geometry.

Aim and Objectives of the Study

The aim of this study was to investigate Students' Perception and Performance across ability levels on GeoGebra Software usage in Learning of Circle Geometry. Specific objectives were to:

1. Find out the perception of students towards the use of GeoGebra software for the teaching and learning of circle geometry.
2. Ascertain if students learning ability in circle geometry is influenced by the use of GeoGebra software.

Research Questions

The following research questions were raised for the study.

What is the perception of students towards the use of GeoGebra software for the teaching and learning of circle geometry?

What is the difference in the mean performance scores of students across ability level when taught geometry with GeoGebra software?

Hypotheses

Two null hypotheses were tested at 0-05 significant level.

$Ho_{1:}$ There is no significant difference between the perception of male and female students taught circle geometry using GeoGebra.

Ho_2. There is no significant difference between the mean performance of students with low, average and high ability level when taught geometry with GeoGebra.

Research Methodology

This study adopted a descriptive survey and one group intact quasi-experimental research design. The population of this study consisted of all the 25,913 senior secondary school students from the 33 public schools in Yenagoa Local Government Area of Bayelsa State.

The sample of the study consisted of 64 senior secondary two (SS2). A purposive sampling technique was used to select the sample school and the simple random sampling techniques was used to select SS2 intact class.

Two instruments were used to collect data. The first instrument used for data collection was a researcher constructed a questionnaire titled "Students Perception on GeoGebra Software" (SPGS). SPGS was used to measure the perception of the students that used GeoGebra software to learn Mathematics. The SPGS was a 13-item questionnaire structured in a four-point Likert scale of 4- Strongly Agree (SA), 3- Agree (A), 2- Disagree (D) and 1- Strongly Disagree (SD) with a criterion mean of 2.50. The second instrument was a Geometry Performance Test (GPT). GPT was used to measure students ability across the different ability levels in circle geometry. GPT was made up of ten (10) subjective questions to be answered by the sample group. Each question was awarded ten marks. SPGS and GPT were face and content validated by two Mathematics educators who made their input in the form of pointing out the weaknesses in the construction of the instruments. The weaknesses pointed out were corrected to arrive at the final document which was used on the sample.

The reliability of SPGS was ascertained using the Cronbach Alpha reliability method to obtain a reliability index of 0.63. The reliability of GPT was ascertained using the test-retest method to obtain a reliability index of 0.82. SPGG was administered to the sample students on a face to face mode after the posttest. The administered instruments were retrieved from the sample on the same day. The same sample was pretested with GPT. After the pretest, the sample was taught circle geometry using GeoGebra software. The same GPT was re-administered to the sample after the treatment. The pretest and posttest were marked and collated. Mean and standard deviation was used to answer the research questions while the independent t-test and Analysis of Covariance was used to the hypotheses at 0.05 significant level.

Results

Research Question 1: What is the perception of students taught circle geometry using GeoGebra?

Table 1: Perception of students towards GeoGebra in circle Geometry

S/N	Item	4	3	2	1	N	Total	$\bar{x}$	SD	Remark
		SA	A	D	SD					
1	I like to use GeoGebra software	24	18	13	9	64	185	2.89	1.67	Sig.
2	GeoGebra software help me to learn geometry concepts.	17	26	12	9	64	179	2.80	1.65	Sig.
3	I feel confident when proving circle theorems using GeoGebra.	23	18	13	10	64	182	2.84	1.67	Sig.
4	I can think critically when using GeoGebra software	9	13	18	24	64	176	2.15	1.96	Non-Sig.
5	I learn faster when using GeoGebra.	24	18	16	6	64	188	2.94	1.69	Sig.
6	I prefer to learn geometry with GeoGebra software.	19	23	12	10	64	179	2.80	1.65	Sig.
7	I am excited when asked to explore the dynamic geometry environment.	20	26	12	6	64	188	2.94	1.69	Sig.
8	GeoGebra helps to increase my performance in mathematics class.	17	24	14	9	64	177	2.77	1.64	Sig.
9	I am happy when the teaching of geometry involves the use of GeoGebra software.	25	21	12	6	64	193	3.02	1.71	Sig.
10	I was engaged in the learning process using GeoGebra.	28	30	2	4	64	210	3.28	1.78	Sig.
11	I was able to make logical connections between circle theorems using GeoGebra.	18	19	16	11	64	172	2.68	1.61	Sig.
12	GeoGebra allows me learn content in playful and motivating way.	32	25	4	3	64	214	3.34	1.79	Sig.
13	GeoGebra allows me to visualize and manipulate geometric concepts.	23	21	11	9	64	186	2.91	1.63	Sig.
	Grand mean ($\bar{x}$)							2.87		Sig.

Table 1 shows that all the items (1 to 13) have means of 2.89, 2.80, 2.84, 2.15, 2.94, 2.80, 2.94, 2.77, 3.02, 3.28, 2.68, 3.34 and 2.91 respectively, which was greater than the criterion mean (2.50) except item 4 that recorded a mean of 2.15. Moreover, the grand mean of (2.87) was also greater than the criterion mean reference. This reveals that students had positive perception towards GeoGebra for the learning of circle geometry.

Research question 2: What is the difference in the mean performance scores of students with low, average, and high ability level when taught circle geometry with GeoGebra?

Table 2: Mean and standard deviation of pretest and posttest scores of GeoGebra and ability levels on students' performance in circle geometry

		Pre-test		Post-test		
Ability Level	N	$\bar{x}$	SD	$\bar{x}$	SD	Mean gain
High	4	53.00	4.24	50.75	6.99	-2.43
Average	40	21.43	7.80	55.35	6.26	33.92
Low	20	10.00	1.84	50.40	7.44	40.40

Results in table 2 show the effect of students' ability level on their performance. The result shows that the high ability students had a pretest mean of 53.00 with a standard deviation of 4.24 and a posttest mean of 50.75 with a standard deviation of 6.99. The difference between the pretest and posttest mean was -2.43. The average ability students had a pretest mean of 21.43 with a standard deviation of 7.80 and a posttest mean of 55.35 with a standard deviation of 6.26. The difference between the pretest and posttest mean was 33.92. And finally, the low ability students had a pretest mean of 10.00 with a standard deviation of 1.84 and a posttest mean of 50.40 and a standard deviation of 7.44. The result above shows that there is no significant difference between the posttest mean performance of students in low, average and high ability level.

Hypothesis 1: There is no significant difference between the perception of male and female students taught circle geometry using GeoGebra

Table 3: Summary of Independent t-test analysis comparing the perception of male and female students towards GeoGebra utilization in learning geometry.

Gender	N	Mean	SD	t	df	Sig. (2-tailed)	Remark
Male	38	54.21	7.204	-1.23	62	.223	Not Significant
Female	26	56.35	6.203				

Results from Table 3 show that the t-calculated (-1.23) is less than the t-critical (2.00) at P=0.223>0.05. Hence, the null hypothesis was upheld. This means that there is no statistically significant difference between male and female student's perception of GeoGebra usability in learning circle geometry.

Hypothesis 2: There is no significant difference in the mean performance scores of students with low, average and high learning ability taught geometry using GeoGebra.

Table 4: Summary of ANCOVA of no significant difference in the posttest performance scores of students with low, average and high ability taught geometry using GeoGebra.

Source	Type III Sum of Squares	df	Mean Square	F	P-value	Sig.
Corrected Model	110.560[a]	3	36.853	.819	.488	> 0.05
Intercept	7178.805	1	7178.805	159.593	.000	< 0.05
Pretest	29.726	1	29.726	.661	.419	> 0.05
Ability Level	107.986	2	53.993	1.200	.308	> 0.05
Error	2698.924	60	44.982			
Total	194763.000	64				
Corrected Total	2809.484	63				

Table 4 shows that the treatment with GeoGebra learning method produces no statistically significant difference P ($F_{0.05}$ (2, 60) = 3.15, p < 0.05 with students of low, average and high ability level. Thus, we accept the null hypothesis of there is no significant difference because of the calculated value Fcal = 1.2 <Ftable = 3.15. Hence, there is no significant difference in the posttest mean scores of students with low, average and high ability level taught circle geometry with GeoGebra.

Discussion of Findings

The result of Table 1: Shows that all the items (1 to 13) have means of 2.89, 2.80, 2.84, 2.15, 2.94, 2.80, 2.94, 2.77, 3.02, 3.28, 2.68, 3.34 and 2.91 respectively, which was greater than the criterion mean (2.50). Moreover, the grand mean (2.87) was also greater than the criterion mean reference. This reveals that students had positive perception towards GeoGebra for the learning of circle geometry.

When asked about the effect and usability of the software, students' responses were mostly positive. That is, they have a positive perception towards the use of GeoGebra. Also, Results from table 2 shows that the t-calculated (1.23) is less than the t-critical (2.00) at P=0.223 > 0.05 set as the α-level. Hence, the null hypothesis was upheld. This means that there is no statistically significant difference between male and female student's perception of GeoGebra usability in learning circle geometry. In each of the items, the percentage of agree and strongly agree is always greater than disagree and strongly disagree. Refer to item one in table 1, it is clear that 37.50% strongly agreed that they like using GeoGebra and 28.13% agreed that they like using GeoGebra. While 20.31% disagreed and 14.06% strongly disagreed. Also, a look at item 13 indicates that GeoGebra software allows students to visualize and manipulate geometric concepts with 35.94% strongly agreeing and 32.81% agreeing to the fact that GeoGebra helps them visualize. While a minimal percentage of the respondent (17.19% and 14.06%) disagree and strongly disagree respectively. In summary, most of the students agreed to the fact that GeoGebra software makes them feel confident and increase their performance through motivation and critical thinking.

The findings suggest that GeoGebra interactive software enable students to explore the geometric environment and thereby engaging them in the teaching and learning process. This finding is supported by (EU, 2013; Arbain & Shukor, 2015) [6, 5] that GeoGebra use to engage students in learning and enable them to think at a higher level that leads to better learning achievement.

Result from table 2 shows the effect of students' ability level on their academic performance. High ability students had a pretest mean of 53.00 with a standard deviation of 4.24 and a posttest mean of 50.75 with a standard deviation of 6.99. The difference between the pretest and posttest mean was -2.43. The average ability students had a pretest mean of 21.43 with a standard deviation of 7.80 and a posttest mean of 55.35 with a standard deviation of 6.26. The difference between the pretest and posttest mean was 33.92. Finally, the low ability students had a pretest mean of 10.00 with a standard deviation of 1.84 and a posttest mean of 50.40 with a standard deviation of 7.44. The difference between the pretest and posttest means of the low ability students was 40.40. However, for each of the ability level except the high level, the posttest means were greater than the pretest means with the low ability students having a higher mean gain followed by the average ability students and lastly the medium ability students. The result meant that all the ability groups are keen to learn the topic using GeoGebra. The software is suitable and user-friendly for the ability groups.

Also, table 4 shows that GeoGebra learning method produces no statistically significant difference P ($F_{0.05}$ (2, 61) = 3.15, $p < 0.05$ between the posttest scores of the low, average and high ability levels. Thus, the null hypothesis of there is no significant difference cannot be rejected since the calculated F-value = 1.20 <Ftable = 3.15 at 0.05 level of significance. Therefore, we conclude that there is no significant difference in the posttest mean scores of students in low, average and high ability level taught using GeoGebra.

The improvement in performance across ability level as observed may be as a result of the potentials and productive capabilities embedded in the software as it offers students many opportunities in terms of drawing accurate shapes with little effort and time as well as observing those drawing and viewing their results on the graphics interface. Its engagement, self-directed and collaborative strategies are not left out as elements that may have improved the students learning capabilities and understanding. Technology plays a significant role in facilitating learning as it encompasses some effective educational methodology like collaborative and self-directed learning (Mohammed & Abdulghan, 2017) [8].

The finding is in conformity with the experiment carried out by Seloraji and EU (2017) [11] on students' performance in geometrical reflection using GeoGebra, where results show statistically significant difference across ability levels. Other researchers that came up with similar results are; Anyanwu, Ezenwa and Gambari (2017) [4] found no significant difference in the posttest mean scores of high, medium and low ability students taught using animated text, animated with narration and the conventional method.

Conclusion

This study concluded that students' perception on the use of GeoGebra software in the teaching and learning of circle geometry was positive and students of the different ability levels benefitted from its use.

Recommendations

Based on the findings of this study, it was recommended that:

The government should endeavour to equip schools with functional computer laboratories. Mathematics teachers should incorporate GeoGebra and other Mathematics software in the teaching of Mathematics concepts.

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