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Effectiveness of Handheld Calculator usage on Students' Performance in the learning of algebra, Speed and Accuracy Factors

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ABSTRACT

The main purpose of the paper was to investigate the effectiveness of handheld calculators on students' performance in the learning of algebra and to construct a correlation analysis on calculator usage and performance in the Edinaman SHS in Ghana.

The descriptive and quantitative research designs were used to examine whether there are differences in the means of the post-test and the pre-test after conducting the two tests for the students without and with the used of the handheld calculators. The data was collected in the form of test scores obtained by students from the pre-test and post-test.

The student population of Edinaman Senior High School is about 2400**.** The school is a mixed school with girls more than boys. The school runs five programs for all the three year levels. As a representative of the whole municipal schools, a random sampling technique under the probability method was used. This technique was used in order to conduct and record accurate study of the problem.

Test and observation for collecting data for the paper. The researcher employed software called Statistical Package for Social Science (SPSS) software version 17.0. The researcher analysed the data under pair sample t-test to compare the means between the two tests. Appropriate tables, charts, frequencies were generated for analysis and interpretation using the correlation model.

From the analysis, the two means were different. The mean for the pre-test is 13.56 and the post-test mean is 25.23. Though, there are differences one cannot determine whether it is significant or not. But from table 4, the significant figure in column 4 is 0.000 and also table 6, column 9 is 0.000. These figures implied that the difference between the pre-test and the post-test is significant. Since the p-value 0.05 is greater than the significant value 0.000, Researcher, therefore reject the null hypotheses that there is no difference in the means between the pre-test and post-test. The researcher accept the alternative hypotheses that there is indeed difference between the pre-test and post-test. However, handheld calculators are the most effective technological instrument for better performance in the study of algebraic mathematics in the Edinaman Senior High School in the Central region of Ghana.

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KEYWORDS: Effectiveness, Handheld, Model, correlation, Calculators, Analysis

INTRODUCTION

Mathematics is the study of numbers, quantities or shapes. It can also be explained as the science of reasoning and computations. According to Green (2011), mathematics is the languages that guide us to describe ideas relationships drawn from the environment. English Dictionary (2017) indicates that, mathematics is the science of numbers and shapes. Mathematics is one of the compulsory subjects taught in almost every school worldwide and at all levels in our Ghanaian schools.

The mathematics curriculum (2010), shows that mathematics has so much importance that cut across all areas of life. Development in almost all aspects of life is based on the effective knowledge of mathematics. It is for this reason that the educational curriculum of Ghana places great emphasis on the study of mathematics at all levels of schooling to develop in all life. For instant, mathematics is necessary for banking, technology, and industrial, designing and playing of games among others in our everyday interactions.

Mathematics teachers had to choose most important principle for the learning of mathematics; they would probably allude

to the important of active mathematical experiences. One intriguing way of adding an element of active experienced to mathematics class is the used of handheld calculators.

However, reports on effectiveness of handheld calculators abound with concerns over the apparent performance of students at the secondary level of formal schooling. In the Edinaman in KEEA Municipality, for example, records show that calculators are powerful learning tools that allow students to experience the richness and value of mathematics by greatly reducing the need to execute paper - pencil computations and algebraic manipulations.

Mathematics enables one to make the invisible to be visible, thereby solving problems that would be impossible otherwise with the help of technology. Tajudin (2011) indicated that, mathematics has grown substantially in last fifty years as a result of instrument available to aid mathematics learning by students has changed drastically. Mabula (2012) tell us that, the technological advancement era, keeping up with the latest innovations and inventions that technology can offer is essential in order to be relevant now in future.

Odhiambo and Toilli (2013) conducted their study and came out with findings that, technology advances at higher speed, a poor mathematics performance in schools short changes the students future and endangers the property nation's security. He further indicated that, students negative attitude toward mathematics, fear of mathematics, inadequate qualified teachers and inappropriate teaching materials were some of the poor performance in mathematics.

According to Biotenbeck (2011), He defined teaching practices as what teachers do in the classroom, how they apply technological methods of teaching. Mtitu et al (2014) supported that teachers have to apply technological methods of teaching that actively involved students in the teaching and learning process.

Furthermore, calculators are powerful learning tools that allow students to experience the richness and value of mathematics by greatly reducing the need to execute paper-and-pencil computations and algebraic manipulations. The calculator is rapidly becoming an accepted and often preferred mode of computation in everyday life and business at all levels. Indication shows that, implementing calculators in mathematics curricula will allow student to learn more quickly and efficiently while keeping them engaged in what they are learning. By reducing the emphasis on learning computational algorithms, more time will be available to spend on sharpening problem solving, mental arithmetic, estimation skills and more applications can be considered hence the students who were previously turned off by tedious computations may now be more inspired to explore the richness of mathematics.

Teachers in many countries do not believe that the calculator is appropriate for students for they see the dangers such as regular use will result in weakening of basic facts and paper-and-pencil algorithm for computation, may hinder development of number concept, students will become calculator dependant, student will become more likely to accept incorrect answers from the calculator and if students use the calculator they will not learn to think (Friel, 2003). There is the need to help dispel the calculator myths such as calculator use does not require thinking, use of calculator will harm students mathematics achievement, computations with calculators are always faster and calculators are useful only for computation. The handheld calculators in Senior High School education help to sharpen students' skills in mathematics, values and formulas which initially students could not confront can now be dealt with easily (Karpie, 2013). Calculators make things faster, useful and convenience rather than it coming to replace the traditional paper-pencil computational method (Artigue, 2002).

According to Hoyles and Lagrange (2010) of New York's students attitudes towards calculator and achievement in mathematics found no significant difference between the treatment group which used calculator and the control group which did not used calculator. Notwithstanding, their results indicated that appropriate use of calculator in classrooms can improve students attitudes. A major concern about using calculators in class and in assessment is that students would lose their traditional by-hand skills. Pape et al, (2011) reported that facility with traditional by-hand skills as measured by mean score data on a technology indicates that in general the mathematical methods calculator cohort perform at least as well as the Mathematical methods non-calculator cohort on related questions. In particular the distribution of student scores for each cohort across the full range of marks show that at the top end, the performance of the two cohorts is essentially the same; at the bottom end, the performance of the Mathematical Methods calculator cohort tends to be better, while across the range of marks the Mathematical Methods calculator cohort consistently achieved a slightly higher score than the non-calculator group. These results suggested that in the main calculator use compared with non-used has either positive or at worst neutral effects on students' abilities and that the use of calculator does not lead to reduced procedural skills. The increasing availability of technology and its use in mathematics changes quite profoundly the way mathematics is assessed. In the review of technology and assessment in mathematics, Graham et al. (2008) pointed out that current assessment practices are struggling to keep pace with the use of technology for doing and teaching mathematics, particularly for senior students. More specifically in assessing mathematics changed by technology, there are fundamental issues about what mathematics is valued, how it should be taught and how it should be assessed Curriculum Council (2002).

The mathematics principle: Assessment should reflect the mathematics that is most important for students to learn. The learning principle: Assessment should enhance mathematics learning and support good instructional practice (Albert, K., et al, 2015)

The equity principle: Assessment should support every student's opportunity to learn important mathematics.

Calculators in particular, have indeed changed the way mathematics is taught and the way students learn (Kitta, 2004). According to Mayrath et all, (2011) the general view was that before computers and calculators, students needed to spend time mastering and becoming fluent and proficient in using paper-and-pencil computational and manipulative techniques, but that today much of this time can be spent on developing deeper conceptual understanding and valuable critical-thinking and problem-solving skills.

According to Rakes et al. (2011) examined 82 studies about methods of instructional improvement in algebra. They grouped the studies using five categories namely implementation of new curricula, technology-based curricula, instructional strategies, manipulative, and technology tools. They found statistically significant positive effect size in each of the five categories, underscoring the importance of technology-related factors. Educational technology is making a modest difference in learning of mathematics. It is a help, but not a breakthrough. Students are able to carry out voluminous work with the shortest time possible. There is a growing body of studies illustrating how technologies can potentially be used to enhance learning and teaching; for example in areas of Algebra (Hoyles and Lagrange, 2010). There is more specifically reference to the use of handheld calculator. Jones (1976) highlighted major areas such as new explorations of mathematical invariants, active linking of dynamic representations, engagement with real data and simulations of real and mathematical technologically relationships.

Theoretical framework of instrumental genesis draws out the underlying complexity involved in using technologies in the learning of mathematics. Each user has to go through the process of working out the role plays in their learning, deciding when calculator could be used and when a task might be better done by hand, and how to balance the two (Shirley et al, 2011). Clearly it would require time and effort for both the student and the teacher to learn to use digital technologies, including handheld calculators, in appropriate ways before expecting improvement in some aspects of mathematics learning. Another significant area in researching the use of technology in the learning mathematics concerns student attitudes and behaviors. Surveying students' attitudes towards their use of hand held calculators, one could found out that, those who are better in mathematics tend to feel that they benefitted more from the use of handheld calculators. Research also revealed that while there was not much of a gender effect, male students have considerably less problems working with the calculator and use it a lot more in other lessons than female students. In another study of effects of attitudes and behaviours on learning mathematics with computer tools Liu and Hwang (2010) found that improvements in conceptual understanding can be predicted from student attitudes towards mathematics and mathematical computer tools. They suggested that student attitudes towards mathematics and mathematical computer tools have a moderate impact on the extent to which intended learning outcomes of using such a tool are realized, in terms of both improved insight into the targeted mathematical concepts and technically and conceptually correct use of tool techniques". Issues surrounding the use of technology in the mathematics classroom are multi-dimensional and complex. The role of the teacher amidst the challenges of teaching mathematics with digital technologies is evolving (Pape et al., In analyzing these factors and gauging teacher readiness for integrating technology into their pedagogy, the literature provides various theoretical frameworks. For example, Shirley, M. L., et al (2011) use the theory of instrumental orchestration; and Mishra and Koehler (2006) draw from the notion of Pedagogical Technology Knowledge as central to knowing how to teach mathematics with technology. Mishra and Koehler (2006,) highlighted a significant problem with seeing technology as constituting a separate set of knowledge and skills that has to be learned, and the relationship between these skills and the tried and true basis of teaching (content and pedagogy) is non-existent or considered to be relatively trivial to acquire and implement". They then outlined the central constructs of Technological Pedagogical Content Knowledge and proposed the framework about the overlaps of knowledge of subject content, pedagogy and technology.

IMPORTANCE OF CALCULATORS

Calculators have indeed changed the way mathematics is taught and the way students learn. According to Waits and Demana (2000), the general view was that before computers and calculators, students needed to spend time mastering and becoming fluent and proficient in using paper-and-pencil computational and manipulative techniques, but that today much of this time can be spent on developing deeper conceptual understanding and valuable critical-thinking and problem-solving skills. In another review, Rakes et al. (2011) examined 82 studies about methods of instructional improvement in algebra. They grouped the studies using five categories namely implementation of new curricula, technology-based curricula, instructional strategies, manipulative, and technology tools. In another meta-analysis, Pape, S.J, et al. (2013) examined 74 studies and concluded that: Educational technology is making a modest difference in learning of mathematics. It is a help, but not a

breakthrough. Students are able to carry out voluminous work with the shortest possible time.

METHODOLOGY

The study uses both descriptive and quantitative research designs.

Correlation analysis model

This study uses a statistical test to determine the degree of relationships between the two variables (set of scores) without trying to influence those variables. In this study, correlation coefficient would be used to describe the degree to which the two quantitative variables are related.

Linear regression model

Linear regression model was also used to deduce the concurrent validity of the test results.

The linear model

$$y = \beta_0 + \beta_1 X + \varepsilon \quad \text{.....(1)}$$

Where,

- ***y*** denotes the dependent variable;
- ***X*** denotes the independent variable;
- $\boldsymbol{\beta_0}$ denotes the y-intercept;
- $\boldsymbol{B_1}$ denotes the slope of the line, and
- $\boldsymbol{\varepsilon}$ denotes a random error.

The independent variable ***x*** is viewed as controlled by the experimenter, so it is considered as non-stochastic whereas ***y*** is viewed as a random variable with

$$E(y) = \beta_0 + \beta_1 X \text{.....(2)}$$

and

$$Var(y) = \sigma^2 \text{.....(3)}$$

Sometimes X can also be a random variable. In such a case, instead of simple mean and simple variance of y, we consider the conditional mean of y given $X = \chi$ as

$$E(y/\chi) = \beta_0 + \beta 1\chi \text{..... (4)}$$

and the conditional variance of y and given $X = \chi$ as

$$Var(y/\chi) = \sigma^2 \text{..... (5)}$$

Hypotheses of the study

The hypotheses of the study were:

1. Null hypothesis

$\mu_1 = \mu_2$

2. Research/alternative hypotheses

$\mu_1 \neq \mu_2$

RESULTS AND DISCUSSION

The results obtained from the data are presented and all the necessary explanations and discussions are provided for better understanding of the study and its implications. The results, the outcomes of the various statistical procedures used in analyzing the data collected. The results served as the foundation for interpretation, discussion and drawing conclusion for the purpose of achieving the objectives.

Table 1: Paired Sample Statistics

Paired Sample Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-Test Marks obtained by Students	13.56	86	3.201	.345
	Post-Test Marks obtained by Students	25.23	86	3.940	.425

Source: *Field data, 2020.*

Table 1 represents the paired sample statistics. The total number of participants in the study is 86 students. The mean mark for the pre-test is 13.56 as against the mean mark for the post-test being 25.23. In the pre-test the students were given a test in Algebra and were not allowed to use calculators. The results of that test were recorded as pre-test. After the researchers taught the students for a period of time and introduced the students to application of technology in Mathematics, another test was conducted dubbed post-test using the same test item. This time around the students were allowed to use calculators except programmable calculator for the test with the same time given as the pre-test. These marks are also recorded.

Table 2: Group Statistics of Gender

Group Statistics					
	Sex of Student	N	Mean	Std. Deviation	Std. Error Mean
Pre-Test Marks Obtained by Student	Male	40	13.85	3.431	.542
	Female	46	13.30	3.003	.443
Post-Test Marks Obtained by Student	Male	40	26.05	3.336	.527
	Female	46	24.52	4.309	.635

Source: Field data, 2020.

Table 2 refers to the group statistics of Gender (males and females). This means that the classes that were used for the test had 40 boys and 46 girls. Their performances are also summarized based on the gender. In the pre-test, the mean mark for the males was 13.85 and the females were 13.30. Though the difference between the performances of the gender is not that much, still it's giving the indication that the males did better than the females.

Also, the participant performance in the post-test is group into males and females. In the post-test, there has been a general improvement in their performances. It still shows that the male students did better than their female counterparts. The mean mark for the females was 24.52 and that of the males was 26.05.

Table 3: Gender of Student

Gender of Student					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	40	46.5	46.5	46.5
	Female	46	53.5	53.5	53.5
	Total	86	100.0	100.0	100.0

Source: *Field data, 2020.*

As stated earlier, the total number of students who took part in the study with their corresponding percentages. For the 86 students, 40 of them are males representing 46.5% of the total sample. The females were also 46 representing 53.5% of the total number.

Table 4

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	Pre-Test Marks Obtained by Students & Post-Test Marks Obtained by Student	86	0.630	0.000

Source: *Field data, 2020.*

Table 4, represents the paired sample correlation between the pre-test and the post-test. Observing critically from the table, column 3 shows the correlation. The figure which is positive 0.630 means that there was relationship and the relationship was strong in the paired correlation. When multiplied 0.630 by 100%, the result is 63% and this shows positive strong relationship. Now the significance figure is less than 0.5 which is the p-value. Since the researchers are considering the based on 95%, the 0.000< 0.05. This shows that relationship was significant.

Table 5

Statistics				
		Sex of Student	Pre-Test Marks Obtained by Students	Post-Test Marks Obtained by Students
N	Valid	86	86	86
	Missing	0	0	0
Mean		1.53	13.56	25.23
Median		2.00	14.00	26.00
Std. Deviation		.502	3.201	3.940
Variance		.252	10.250	15.522

Source: *Field data, 2020.*

Table 5 contains statistics about the whole of the population with valid responses of 86. If you observe critically from the table, you will notice that the median mark for the pre-test was 14. The median mark for the post-test too was also obtained as 26 indicating better performance in the post-test than the pre-test.

Table 6.

Paired Samples Test

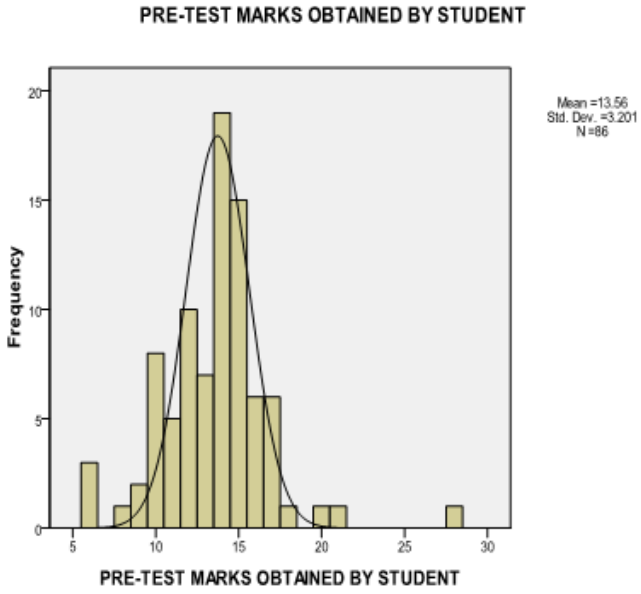
			Paired Differences									
						95% Confidence Interval of the Difference						
			Mean	Std. Deviation	Std. Error Mean	Lower	Upper	T	Df	Sig(2-Tailed)	Df	Sig.(2-Tailed)
Pair 2	Pre-Test Obtained Marks Test Obtained	Post - Marks Obtained	-11.674	3.142	.339	-12.348	-11.001	-34.462	85	0.000	85	.000

Source: *Field data, 2020.*

The first test called pre-test was used as a diagnostic tool by the researchers to determine the performance of the students. After identifying the problem, they employed an intervention which sought to remedy the situation at hand. The researchers allowed the students to use
calculators in the second test called the post-test. From the table above, the standard deviation is 3.142 and the t-value is -34.462 and the degree of freedom (df) 85.

Graphs for the Data

Figure 1

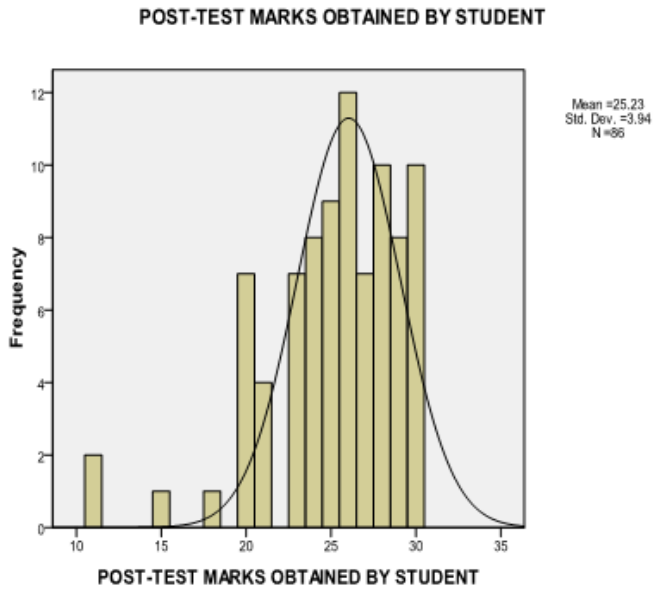


Source: *Field data, 2020.*

Figure 1 shows a histogram with a normal curve superimposed on it. The histogram shows that the data is normal distributed and hence the bell shape of the normal curve. Even though, the marks were scored out of 30, most of the students did not obtain marks up to half of 30. The tallest bar in the histogram is pegged around the 14th mark hence the median in table 5 is -13.56 a very weak performance was obtained.

A critical observation of the table has a few outliers. Outliers are extreme values in a data set. From the table, some two bars lying at the extreme ends of the normal curve. Those bars are marks obtained by students so low or very high from the rest of the students.

Figure 2



Source: *Field data, 2019.*

Figure 2, illustrated a histogram with a normal curve superimposed on it. The histogram was drawn from the results of the post-test. This time around the normal curve has shifted from the left to the right indicating that the mean and the median have moved higher than half of the marks which

is 15. The data therefore we say has skewed to the right since the tail is at left. The marks were scored out of 30; most of the students this time, obtained marks more than half of 30. The tallest bars in the histogram are now pegged around the 26. The median in table 5 is 26.00

A critical observation of the table has a few outliers. From the graph, some two bars lying at the extreme end of the normal curve. Those bars are marks obtained by students that are so low from the rest of the students. But this time, the bars representing the lower mark are now on the left-hand side.

SUMMARY

The outcome of the various statistical procedures used in analyzing the data collected and coded indicates that, the face validity of the test appeared to measure what it purported to measure. However, handheld calculators are effective technological instruments on the performance of students in the learning of algebra once there is a strong positive correlation in the two test conducted by the researchers.

The degree of the relationship was also strong since the value of the correlation coefficient was greater than 0.60; that is, r > 0.60. The results imply that, the introduction and the used of handheld calculators have massively improved students' performances in the post test score and analysis. It means, the used of handheld calculators was testified by both researcher and students as the most effective technological tool for better performance in the study of algebra in Edinaman Senior High School in the Central region of Ghana.

FINDINGS OF THE STUDY

In the course of the research the following were the findings the researcher observed;

- From figure 1, it showed a histogram with a normal curve superimposed on it. The histogram shows that the data is normal distributed and hence the bell shape of the normal curve. Even though, the marks were scored out of 30, most of the students did not obtain marks up to half of 30. The tallest bar in the histogram is pegged around the 14^{th} mark hence the median in table 5 is -13.56 a very weak performance was obtained due to insufficient calculators
- In the course of the research it was observed that most of the students could not do the pre-test due to insufficient skills in the manipulation of the handheld calculators. This can be testify from table 6 which has a few outliers.
- From table three (3) it was noticed that the population in the class was large and for that reason teachers were not getting adequate chance to assist them in the use of calculator.

CONCLUSIONS

From the analysis, the two means are different. The mean for the pre-test is 13.56 and the post-test mean is 25.23. Though, there are differences one cannot determine whether it is significant or not. But from table 4, the significant figure in column 4 is 0.000 and also table 6 column 9 is 0.000. These figures imply that the difference between the pre-test and the post-test is significant. Since the p-value 0.05 is greater than the significant value 0.000, therefore reject the null hypotheses that there is no difference in the means between the pre-test and post-test. We accept the alternative hypotheses that there is indeed difference between the pre-test and post-test. However, handheld calculators are the most effective technological instrument for better performance in the study of algebraic mathematics in the Prestea Senior High Technical School in the western region of Ghana.

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