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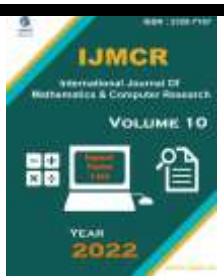

Impact of Malmath Application on Students' Achievement on Properties of Quadratic Graph

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ABSTRACT

The study looked into how the MalMath Application integration affected how well students performed when learning about the characteristics of a quadratic graph and how they felt about using the program. A quasi-experimental design was adopted in the investigation. The pre-questionnaire results were used to create the control and experimental groups (i.e., students who have access to smartphones and those who do not have access to smartphones respectively). While receiving treatment, the experimental groups' lessons included the MalMath app, whereas the control group received traditional training. For the study in Ghana, a Technical Senior High School's sample of N = 80 students were readily and purposefully selected as control and experimental groups. This study's theoretical underpinnings were informed by constructivism. The experimental group's findings regarding the scores of male and female did not show a significant difference, but the post-test results for the two groups showed a significant difference in the findings regarding the scores of female students. The findings of the post-questionnaire showed that students' attitudes on the usage of MalMathApp in teaching quadratic graphs are favourable, and they are willing to utilise it for other mathematical topics. It was advised that teachers use MalMath App to teach and learn about quadratic graph characteristics and any other mathematics courses.

KEYWORDS: MalMath application, Students' achievement, Quadratic graph

INTRODUCTION

Information Communication Technology (ICT) is a dominant force in the 21st century, and a country's failure to train its human resources in that direction will cause that nation to perish. Any person, town, or nation that resists or refuses to join these forces of progress will be left behind and abandoned to suffer in ignorance, poverty, and backwardness forever, asserted (Talabi, 2003). Every strong economy has the potential to concentrate on ICT. ICT now dominates the educational sector. One of the most notable discoveries of the 21st century is the development of smartphones, which are internet-enabled gadgets that contain computer software and applications (Foen, Hassan, Nor & Malek, 2017).

Despite the fact that ICT is useful for many fields, it is not without drawbacks. Social media, according to Paul, Baker, and Cochran (2012), are a factor in students' subpar academic achievement. They discovered that students' academic performance declines the more time they spend on social media platforms. In addition, it was mentioned in the Ghana Country Report (December 2017) that students are exposed to online dangers such as pornographic images, financial fraud, and the sharing of violent texts and images.

In contrast, research has shown that the importance of using ICT in education, particularly in our second-cycle institutions, cannot be overstated. According to Wang, Chen, and Liang (2011), social media may appear to be a waste of time, but it actually helps students gain critical social and academic skills and become engaged citizens who create and share material. Many academics, like (Lee, Waxman, Wu, Michko & Lin, 2013; Li & Ma, 2010; Mensah-Yawson, 2019; Supandi, Ariyanto, Kusumaningsih & Aini, 2018; Zhang, Trusell, Gallegos & Asan, 2015) have advocated for the adoption of

ICT-based learning environments in our various educational institutions. The Association of Mathematics Teacher Educators (AMTE, 2015) emphasised the importance of technology tools for teaching and learning mathematics in the 21st century. It is possible for teachers to maximize the potential of technology to deepen students' knowledge, spark their interest, and increase their performance in mathematics by using it successfully in the classroom (NCTM, 2008). Given the significance of graphs and equations in mathematics, the quadratic concept is one of the most crucial concepts in education, but most students struggle with it (Benning & Agyei, 2016). The quadratic graph's utility and its application to real-world situations are both explicitly discussed in the curriculum, where it is definitely stated that teachers should adopt and encourage students to utilise computers to examine the structures of quadratic graphs. The following researchers backed up this assertion by recommending that graphing technology be used while instructing graph work (Heller & Curtis, 2006; Khoju & Miller, 2005; Ellington, 2003).

Girls do not seem to be particularly interested in using ICT tools, according to studies (Barkatsas, Kasimatis & Gialamas, 2009; Ikpeama, 2009; Schumacher & Morahan, 2001). Numerous academic studies have found that when technology is used in the classroom, male students do better than female pupils (Meggiolaro, 2017; Sainz & Eccles, 2012).

Schools in several nations have started allowing pupils to use their own mobile devices in the classroom, such as laptops, tablets, or smartphones, a practice known as "Bring Your Own Device" (Alberta Education, 2012; Ferreira, Moreira, Santos-Pereira & Durao, 2015; Song, 2014). Knowledge of technology aids students in easily gathering information, encourages cooperative learning, allows for exploratory learning outside of the classroom, and promotes game-based learning (Klopfer, Sheldon, Perry & Chen, 2012; Lan, Sung, & Chang, 2007; Liu, Lin, Tsai & Paas, 2012). Making a purposeful effort to encourage student learning should be done as the paradigm for online activities shifts from desktop computers to mobile devices such as laptops, tablets, and smartphones (Prensky, 2005). Wang, Chen, and Liang (2011) believe that technology is essential to the success of today's students as it gains popularity. Most students have access to and are familiar with utilising mobile devices like smartphones and tablets, so if they are introduced to mathematical applications like the MalMath App, they would not have any trouble using them to learn. Due to their familiarity with using these mobile devices, educators are also better able to connect with students (Ward, Finley, Keil & Clay 2013). Since a few years ago, mobile devices and their applications have become the most common and important for human learning due to their utility, usability, ease of use, and accessibility (Malavolta, Ruberto, Soru & Terragni, 2015). Students are unable to read from the quadratic graph, according to the chief examiner's report (2020). In order to help students, understand key vocabulary concepts for graphing, Bixler (2014) found that teachers might employ mobile apps. According to him, students can use this software to help explain quadratic graphs and the necessary vocabulary, including "axis of symmetry," "roots," "maxima," "minima," and "vertices."

ICT integration can therefore be used to attract students' attention, especially in institutions where there is a lack of enthusiasm for mathematics (Mensah-Yawson, 2019). It has been difficult to use computers in the classroom during class time for particular subject areas at our Ghanaian Technical Senior High Schools. This study focuses on using the mobile application program MalMath to improve students' ability in learning the characteristics of quadratic graphs in response to this challenge. Mathematics is taught at every level of our educational system, from primary schools to universities, due to its unavoidable practical applications. Additionally, everyone occasionally requires help solving mathematical problems, regardless of how proficient they are in the subject. Therefore, in the absence of a teacher or acquaintance who could be of assistance, we can turn to the internet, consult reference books available in bookstores, or use a new math-solving app called MalMath. They continually maintain low achievement in mathematics (homework, classwork, end-of-term tests, and final exams), despite the fact that mathematics permeates every part of their lives, and they view mathematics as a topic that should only be studied by the most talented students. Such students require specialised education that takes into account such perspectives in their learning process. Therefore, it is crucial to adopt creative approaches to teaching. Applications for mobile technology are expanding, are portable, and are useful in our daily lives (Benning, 2019).

RESEARCH QUESTIONS

The following research questions were answered:

1. What is students' achievement on properties of quadratic graph?
2. What is students' achievement on properties of quadratic graph based on gender?
3. What is female students' achievement on properties of quadratic graph?
4. How do Technical Senior High students perceive the effectiveness of MalMath App integration in the studying of properties of quadratic graph?

HYPOTHESIS

1. H_0: There is no statistically significant difference between the post-test mean scores of the control and the experimental groups after the treatment.
2. H_0: there is no significant difference between the mean scores of the male and female students in the experimental group.

3. H_0: there is no significant difference between the mean scores of female students of the control group and the female students of the experimental group.

Hypothesis 1 was formulated to further answer research question one. The analysis was done on the post-test scores of the control and experimental groups to determine whether there was a statistically significant difference in the mean scores of the post-test between the two groups.

Hypothesis 2 was also formulated to find out if there was any statistically significant difference between the post-test scores of males and females of the experimental group. This hypothesis was formulated to answer research question two.

Hypothesis 3 was also formulated to find out if there was any statistically significant difference between the post-test scores of female students of the control group and female students of the experimental group. This hypothesis was formulated to answer research question three.

THEORETICAL INFERENCES

This study is based on the constructivist theory of teaching and learning. The constructivism theory was chosen for this study because the researchers believe that, students can construct their learning through a social environment with little help, and various constructivist supports this assertion. When students are allowed to interact with colleagues and learning materials in their immediate environment they begin to think critically and make discoveries. The perception of the student has changed from that of a passive receiver of knowledge to that of an active constructor of knowledge (Mohan, 2019).

In addition, Constructivism is central to modern teaching techniques because it simply says that we learn by doing, reflecting, adapting, and through problem-solving (Roblyer & Doering, 2013). In a constructivist classroom, the teacher becomes a guide, facilitator, and mentor. Constructivist classrooms can help students to develop their intelligence, and learn through discovery and scaffolding (Roblyer & Doering, 2013). Most of these philosophers believed the teacher cannot teach knowledge to students, students must acquire it for themselves. So, student-centred learning is a fundamentally constructivist-learning approach. When this theory is used in the classroom, it helps the students to; think critically, creatively, experiment, solve problems, ask themselves questions, discover, evaluate, analyse, and present what they have learned in a variety of ways, as a result of this, the learner becomes expert learners (WNET Education, 2019). Agyei (2013) and Liang and Martin (2008), opined that instructional approaches that involved the use of technology have the propensity to support a constructivist pedagogical approach where students explore and reach an understanding of mathematical concepts by concentrating on problems solving process rather than on calculations related to the problems as a result.

Overview of MalMath Application Software

There are numerous studies, which confirm that the use of computer and mobile software enhances the teaching and learning of Mathematics. There are countless numbers of educational apps available for teaching and learning Mathematics in the open market. For example, Calculus Problem Solver, PhotoMath, Math Solver, Mathway, GeoGebra, Microsoft Mathematics and many more. These mathematical applications are used across the world in schools and at homes. Teachers need to purchase some of these apps to use in the classroom, but some of the apps are expensive. However, some apps are free to use by Mathematics facilitators, students and parents in the classroom and at home such as MalMath. Malmath application was launched on May 5, 2015. MalMath is an android application that can solve Math problems with systematic solutions and provide graphic analysis. The App is quite simple to use; just type in a Mathematics problem and press the "solve" or "click" button. In addition, MalMath will present the solution, including the following helpful features. For each problem that is solved, the steps of the solution are provided for the user. However, knowing that some users cannot understand faster than others can, Malmath provides additional sub-steps. Even the sub-steps may contain other steps, until the most detailed explanation that a user may need.

HIGHLIGHTS

One of the unique features of MalMath is highlighting the part of the expression that was changed from the previous step. This provides an intuitive way to understand the steps without having to read the description or analyse the whole expression. Besides, users can enable animations, which means that the problem will be solved each step at a time, using highlights to make it easier for the user to follow the solving process.

Problem Generator

Some students have already learnt the basics of Mathematics and want more exercises to challenge their understanding. "Problem generator" is one of the most helpful features for those students. Problems are generated from various fields: Algebra, Trigonometry, Limits, Differentiations and Integrals. Moreover, there are three difficulty types to choose from: Easy, Medium and Advanced.

Graph Analysis

In MalMath, you can plot functions and it will draw the function or fill the area (depending on the problem). Also, multiple functions are supported, so you can plot two functions at the same time, and compare their graphs. In addition, MalMath will also analyse the graphs. This means that it will

show you a table with points from domain to inflexion intervals.

MalMath is free and can be used offline, which means it will appeal to Technical/high school students, especially low-income students, who cannot afford to buy internet data, expensive study guides or apps.

MalMath's main mission is to provide students with detailed solutions for Math problems in such a manner that they can understand the solving process. Its main objective is not to solve every Math problem but to help students understand the solving process.

Whether you are a student, thriving to improve your Math skills or a parent, trying to help your kid with homework, MalMath is one of the best tools to choose.

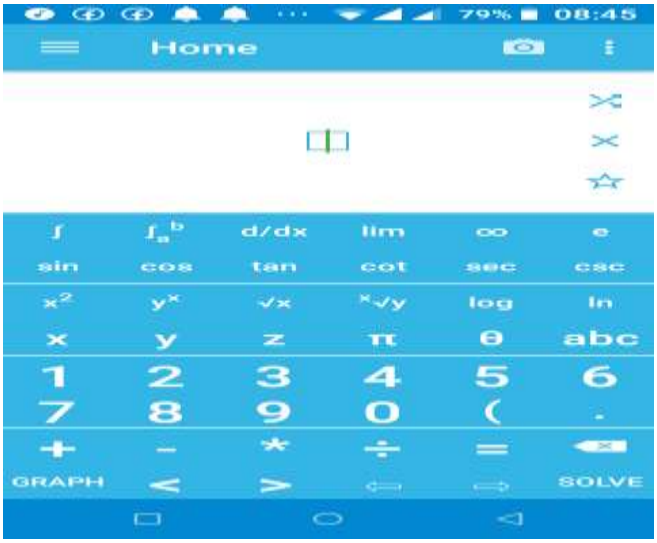

Figure 1: The interface of MalMath App launch on the smartphone.

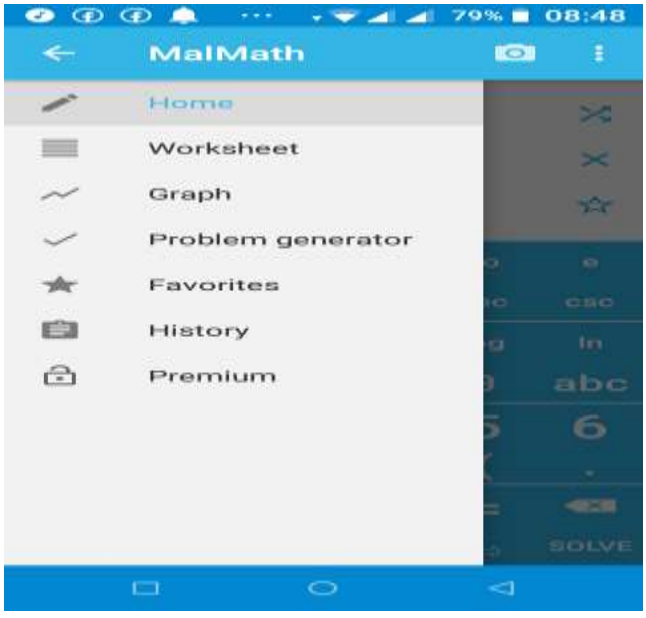

Figure 2: Some features of the MalMath App on the smartphone for students to explore.

The **Home** tap displays the functions. The **Worksheet** is where input is displayed. The **Graph** displays images of a graph. The **Problem generator** creates problems from various fields: Algebra, Trigonometry, Limits, Differentiations, Integrals, and has three difficulty levels to choose from i.e. Easy, Medium, and Advanced. The **Favorite and History** store work examples. With the help of smartphone application using MalMath App researchers guide students to draw quadratic graph as indicated in Figure 3.

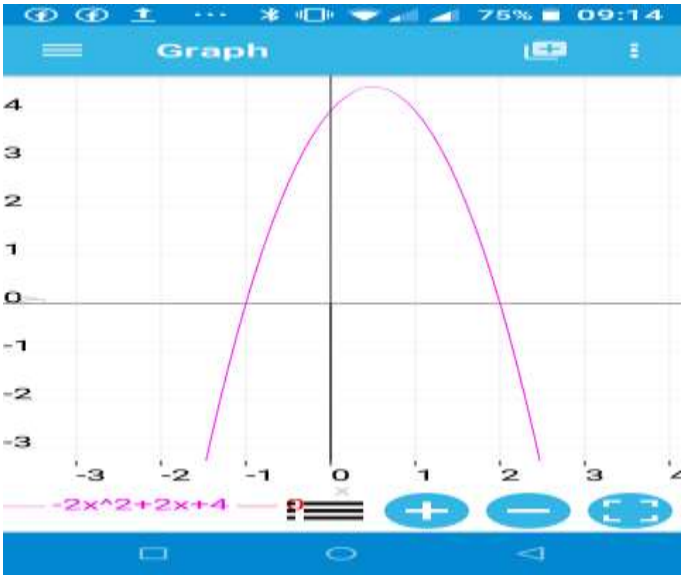

Figure 3: Output of a Quadratic Graph on a smartphone using MalMath App

ICT Integration in Education

Mensah-Yawson (2019), looked at the effect of ICT Integration on SHS students' achievement in Mathematics, the results of the independent samples t-test revealed that there was a statistically significant difference between the experimental group and control group The findings indicated the experimental group, which was taught with ICT, performed better than the control group taught with the traditional method. Armah and Osafo-Apeanti (2012), conducted a similar study to investigate the effect of graphing software on students' conceptual understanding of quadratic functions. The test showed that there was no significant difference between male and female student achievement. They concluded that the integration of graphing software in the Mathematics-learning environment was very effective, male and female students benefited equally and contributed to the pedagogical model for the constructivist. Tuba and Dikkartin-Ovez (2018), conducted a study to examine the impact of instructing quadratic functions with the use of GeoGebra Software on students' achievement and level of reaching acquisitions. The result showed that the experimental group performed better than the control group.

ICT Policy in Education Ghana

ICT has become a tool for national development in the world today, it influences the way a country develops. A country with a high level of ICT experts develops with great speed. In 2003, the Government of Ghana through the Ministry of Education Youth and Sports now the Ministry of Education set up for itself the task of improving upon access, equity, and quality of education delivery in Ghana. In pursuit of this agenda, the Ministry put ICT at the centre of education by developing ICT policy document and in this policy document, it identifies three pillars thus:

- ICT as a learning and operating tool: This pillar would allow for software applications as well as hardware devices to be used as a tool to help manage educational environments.
- ICT to be integrated into the teaching and learning of subjects: This pillar allows ICT to be integrated into all subjects within the national curriculum. This will help teachers and policymakers to make it possible to utilise ICT in all subjects in all scopes of our educational system and by extension, our national life.
- ICT as a career option for students: This pillar allows students to be educated to high levels of technical skill as far as ICT is concerned so that they can, in turn, become relevant at the workplace.

The government desires that through the deployment of ICT in education, the culture and practice of traditional memory-based learning will be transformed into education that stimulates thinking and creativity necessary to meet the challenges of the 21st Century." The Ministry of Education, therefore, saw ICT as "a means, not an end in itself" and in view of this ICT for Accelerated Development (ICT4AD) policy document, Ghana Education Service (GES, 2003) was drafted to help in the deployment, exploitation, and development of ICTs to fast-track the socio-economic development. The main goal is to make Ghana an information-age country and a technology hub nation to help to establish a prosperous society, with an economy that is globally competitive, dynamic, robust, and resilient. The Ghana ICT for Accelerated Development (ICT4AD) Policy represents Ghana's vision in the information age. In the policy document, it was proposed that by 2015, every learner in general, tertiary education, and training institutions will be familiar with the use of ICT tools, but that is not the case now in the country. For the smooth operation of the ICT4AD policy, the Government set up the National Information Technology Commission (NITC), Information Technology Services Divisions/Directorates (ITSDs), and the Ghana Information and Communications Technology Agency (GICTA) to help spearhead the implementation of the policy.

Even though there are tremendous benefits to utilising technological devices in teaching and learning environments, there are drawbacks, such as government and school policy, unavailability of ICT infrastructure, students' and teachers' interest, and technical expertise. Most teachers view these technological devices as distractors (Dyson, Andrews, Smyth & Wallace, 2013; Keengwe, Schnellert & Jones, 2012). They said teachers have expressed concern about the use of mobile devices in their classrooms as they may distract students from learning activities. Making things worse, many schools have banned the use of mobile devices in instruction. Similarly, Yeboah and Ewur (2014) are of the view that, if the devices are not used positively, they will have an adverse impact on students' achievement. Among the adverse impacts, they identified in relation to the use of these tools is that it would take much of the students' studies time, result in procrastination-related problems, destroy students' grammar and spelling, lead to lack of concentration during teaching and difficulty in balancing online activities and academic preparation. Also, Asiedu-Addo, Apawu, and Owusu-Ansah (2016) identify some major problems that hinder the integration of ICT into the classroom and they are: the non-availability of software, lack of computers and other ICT hardware, some software are difficult to use and are expensive.

METHOD

Research Design

This study employed a quasi-experimental research design to determine the impact of treatment on participants. In this type of design, researchers purposely present treatment to a group of students and then observe the sequence of changes that occur in the group (Sekaran, 1992). The design is also justified on the basis that the experiment was carried out in an educational setting. The quasi-experimental design was chosen because it also controls the internal validity threats of the initial group difference and researchers' selection bias since there was no randomisation of the subjects into groups (Handley, Lyles, McCulloch & Cattamanchi, 2018). The approach to this study was a quantitative method. In this study, the independent variable that was being manipulated was the MalMath Software. The dependent variables in this study were the achievement and perception of the student towards the usefulness of the MalMath Software.

Population

The target population for this study was all form three students of a Technical Senior High School (Ledzokuku Municipality) Greater Accra region of Ghana. The year group was chosen because the topic was to be taught at that level. The population size of the year group was 387 students made up of 163 girls and 224 boys, (GES, Ledzokuku Municipal, 2019). The population is heterogeneous and consists of students from various ethnic backgrounds, of which the Ga tribe dominates.

Sample and Sampling technique

The Convenient and Purposive sampling technique was used to select the population and the sample respectively. Convenience sampling is a non-probability sampling method that depends on data collection from population members who are conveniently available to participate in a study (Saunders, Lewis, Thornhill, 2012). It is affordable and easy, and the participants are readily available. The purposive random sampling technique was used because Ferrance (2000), argued that research studies conducted by educators themselves, in a familiar school setting, with their own students, would help solve real problems experienced in schools and thus contribute towards improving teaching and student achievement. Purposive sampling is very useful when a targeted sample needs to be reached quickly (Crossman, 2018).

A questionnaire was administered to 387 students and based on their responses they were put into three groups; 1. those who own smartphones (124 students), 2. those who have access to smartphones but do not use it (187 students), and 3. those who do not have access to a smartphone (76 students). The researchers purposively selected 40 students out of the 124 students who own smartphones to form the experimental group and 40 students from the 76 students who have no access to a smartphone to form the control group. Hence the sample size for the study was 80 students. Forty students were selected for each group to enable the researchers to manage the class size in order to reduce any confounding effect. The rest were exempted from the studies. According to Gay, Mills and Airasian (2012), when at least 10% sample is selected from the population it is categorised as a good sample to make statistical analysis.

Instruments and Data Collection

Test (pre-test and post-test) and questionnaire (pre-questionnaire and post-questionnaire): Test and questionnaire were developed and used in the study. The tests were set by the researchers and reviewed by experts in the field and pre-tested in one of the Technical Schools in Tema which is in the same school category as the sampled school.

Validity and Reliability

The researchers tested for content validity by employing the expertise of a group of experts in the field. Validity is the ability of how accurately a test can measure what it is intended to measure (Fiona, 2020). Content reliability is the extent to which the items or behaviours fully represent the content being measured" (Vanderstoep & Johnston, 2009). Vanderstoep and Johnston added that a researcher could ensure content validity by asking a group of experts to review instruments.

Reliability is the extent to which an instrument is able to give the same results under different conditions, different times, and groups of participants (Vanderstoep & Johnston, 2009). The two scores were analysed using SPSS to estimate the Pearson correlation coefficient, the r = 0.81 which show a good reliability of the test. The closer the result is closer to one (1) the higher the reliability.

Ethical principles

The researchers met the Principal of the school to brief him on the purpose of the study and sought permission from him to use his students for the study. The head later permitted the researchers and copied the Vice Principal of Academics and all heads of departments of the institution for further action.

Additionally, students were assured of confidentiality, which implies that no names but codes, which were given to the students, were required on the test and questionnaire for the researcher to be able to identify and match their performance. Ethics are the behaviour that differentiates between right and wrong and helps to determine the difference between acceptable and unacceptable activities on the part of the researcher (Mensah-Yawson, 2019). Ethical consideration is central in research as the integrity, reliability and validity of the research findings depend largely on the ethical standards underlying the research (Creswell, 2014).

Treatment

The treatment stage was the stage the researchers integrated the use of MalMath Application Software to consolidate the conceptual understanding of properties of quadratic graph and its interpretation in order to achieve the purpose of the study.

The treatment was carried out after the pre-test and pre-questionnaire were administered. The treatment lasted for three weeks. In all, there were five lessons of sixty (60) minutes in each case. The experimental group was taken through the various features on the MalMath and on how to use the MalMath Application in the first lesson; in lesson two, the researchers discussed with students how to use the application to solve quadratic equations and identify the minimum or the maximum values and points of a quadratic graph; lesson three looked at how to use the application to identify the line of symmetry and solve related quadratic equations, lesson four looked at identifying increasing and decreasing values, positive and negative values of quadratic graphs; and in lesson five more questions were solved. Throughout the lessons, students were given the opportunity to explore by entering their questions and coming out with solutions and interpretations. The conventional method of teaching, where the teacher in the teaching process uses a marker, marker board, and textbooks, was applied to the control group. Both groups were taught during the treatment but MalMath app was integrated into the teaching and learning process of the experimental group. The lesson was designed in accordance with the constructivist teaching strategy, which states that learners can build their knowledge structures (Driscoll, 2000; Tracey & Morrow, 2006) and it also follows Tam (2000) four basic instructional strategies of constructivist

learning environments, which states that; knowledge should be shared between teachers and students, teachers and students should share authority, the teacher's role is one of a facilitator or guide and learning groups should consist of small numbers of heterogeneous students. Students in each group met twice in a week for a duration of sixty (60) minutes per meeting and after that, they were given group assignments to be done the next day. The meeting schedules for the treatment (see Table 1) were arranged after normal school contact hours in order not to disrupt the timetable of the schools. After the treatment, students were informed about the post-test and post-questionnaire scheduled for the following week. The researchers taught the two groups.

Table 1: Timetable for treatment.

	Monday	Tuesday	Wednesday	Thursday	Friday
Experimental Group	**Lesson 3:30 – 4:30**	**Group Work**	**Lesson 3:30 – 4:30**	**Group Work**	**-**
Control Group	**-**	**Lesson 3:30 – 4:30**	**Group Work**	**Lesson 3:30 – 4:30**	**Group Work**

RESULTS AND DISCUSSIONS

This section presents the results of the pre-questionnaire administered to 387 students to respond to the questionnaire, out of which 80 students were selected based on the answers they provided to form the control (40 students) and the experimental (40 students) groups.

1. *Are any of these devices available for you to use at home or school?*

Table 2: Number of students to whom the devices are available and not available to them to use at home or school.

	Desktop	**Laptop**	**Tablet**	**Smartphone**
Yes, and I use it	19	51	83	124
Yes, but I don't use it	08	23	13	187
No	360	313	291	76
TOTAL	387	387	387	387

From Table 2, 19 students have access to and use Desktop, 8 students have access to but do not use Desktop and 360 students do not have access to Desktop. 51 students have access to and use Laptops, 23 students have access to but do not use Laptops and 313 students do not have access to Laptops. 83 students have access to and use Tablets while 13 students have access to but do not use Tablets and 291 students do not have access to Tablets. 124 students have access to and use Smartphones, 187 students have access to but do not use Smartphones and 76 students do not have access to Smartphones.

Achievement test results

This section shows the analysis of the Achievement Test (pre-test and post-test) results from both the control and the experimental groups.

Before the treatment, the pre-test scores were analysed and compared to see if there was any statistically significant difference between the control and the experimental groups. The test result shows no statistically significant difference between the control and experimental groups when the independent t-test was conducted, this shows that the groups were homogenous.

Table 3: Descriptive Statistics of Pre-test Scores of Control and Experimental Groups.

Group	**N**	**Maximum**	**Minimum**	**Mean**	**Standard deviation**
Control	40	7	0	2.65	1.79
Experimental	40	6	0	2.13	1.49

From Table 3, the results showed a maximum score of 7 and 6 for the control and experimental groups respectively which was scored out of 10. The minimum score for both the control and the experimental groups is 0. The mean score was 2.65 and 2.13 for the control and experimental groups respectively. Comparing the mean scores of the groups would suggest that the control group performed better with a mean of 2.65 than the experimental group with a mean of 2.13. To test whether the difference in mean scores between the experimental and control groups was statistically significant, independent samples t-test was performed at a 95% confidence interval. The results of this test is shown in Table 4.

Table 4: Independent Samples t-test of Pre-test of Experimental and Control Groups

Groups	N	Mean	Standard Deviation	t-value	df	p-value
Control	40	2.65	1.79	1.43	78	0.16
Experimental	40	2.13	1.49			

The results from Table 4 shows that there was no statistically significant difference between the control group ($M = 2.65$, $SD = 1.79$) and the experimental group ($M = 2.13$, SD =1.49) conditions; (t (78) = 1.43, p = 0.16 > 0.05). This result indicated that both the control and experimental groups were at the same level in terms of conceptual understanding of the concept of quadratic graph before the treatment was carried out.

Research Question 1: What is students' achievement on properties of quadratic graph?

Research question one focused primarily on the impact of MalMath app integration in teaching and learning the concept of properties of quadratic graph. The scores of the post-test of the control and experimental groups were analysed and compared to find out if there was any significant difference between the mean scores. To answer this question the hypothesis below was set up;

Hypothesis:

1. H_0: *There is no statistically significant difference between the post-test mean scores of the control and the experimental groups after the treatment.*

Table 5: Descriptive statistics of the post-test of the control and experimental groups.

Groups	N	Mean	Std. Deviation	Mean difference	Maximum	Minimum
Control	40	4.58	1.69	1.85	8	2
Experimental	40	6.43	1.26		9	4

The results from Table 5 shows minimum and maximum scores of 2 and 8 respectively for the control group and minimum and maximum scores of 4 and 9 respectively for the experimental group in the post-test. The mean scores for the control and the experimental group are 4.58 with a standard deviation of 1.69 and 6.43 with a standard deviation of 1.26 respectively, with a mean difference of 1.85. This result shows an improvement in the mean scores of both groups, when compared with the control and experimental pre-test mean of 2.13 and 2.65 respectively. Also, it can be observed from the results that the experimental group performed better than the control group. To verify whether the mean difference is statistically significant the independence t-test was conducted.

Table 6: Independence t-test of the post-test of the control and experimental groups.

Groups	Mean	Std. Dev.	N	Mean difference	t-value	df	p-value	Effect size
Control	4.58	1.69	40	1.85	5.55	78	0.00	1.26
Experimental	6.43	1.26	40					

The results from the independent t-test revealed that there was a statistically significant difference between the mean scores of the control group (mean = 4.58, SD = 1.69) and the experimental group (mean = 6.43, SD = 1.26) with a gain mean score of 1.85 for the experimental group. The t-test also revealed a significant difference between the means of the two groups (t(78) = 5.55, p = 0.00 < 0.05). According to Cohen (1988), if the p-value is smaller than the alpha value, it does not mean there is any statistically significant difference between means. Hence, Cohen's d was calculated to standardise the mean difference. The Cohen's d effect size of 1.26 suggested a large practical significance. Cohen interpreted the values of the sizes as follows; small ($d<0.5$), medium ($0.5<d<0.8$) and large ($d>0.8$). This result shows that the students taught with MalMath app performed better than those taught using the conventional teaching approach. This is consistent with the findings of the following researchers (Oguz & Abdullah, 2012; Siaw, 2016; Supandi et al., 2018; Tuba & Dikkartin-Ovez, 2018).

Research question 2: What is students' achievement on properties of quadratic graph based on gender?

Hypothesis

2. H_0: *there is no significant difference between the mean scores of the male and female students in the experimental group.*

Table 7: Independent Samples t-test of post-test scores of male and female experimental group.

Experimental Group (Gender)	Mean	Std. Dev.	N	Mean difference	t-value	df	p-value
Male	6.28	1.24	25	0.28	0.69	38	0.50
Female	6.00	1.25	15				

The results from Table 7 shows a slight difference between the male (*M=6.28, SD=1.24*) and female (*M=6.00, SD=1.25*) with a mean difference of 0.28. The findings of the male and female scores did not differ significantly in the experimental group (*t(38)=0.69, p=0.50>0.05*). This result indicated that both the male and female students were at the same level in terms of conceptual understanding of the concept of quadratic graph after the treatment. Hence, the researcher failed to reject the null hypothesis. This result supports the findings of (Armah & Osafo-Apeanti, 2012; Gunamala & Sneha, 2016; Oguz & Abdullah, 2012; Wontemgegn, 2018).

Research question 3. What is female students' achievement on properties of quadratic graph?

Hypothesis

3. *H_0: there is no significant difference between the mean scores of female students of the control group and the female students of the experimental group.*

Table 8: Independent Sample t-test.

Group	Mean	Std. Dev.	N	Mean difference	t-value	df	p-value	Cohen's d
Female control	4.76	1.95	17	1.9	-3.20	30	0.003	1.15
Female experimental	6.67	1.29	15					

The results of the independent sample t-test (see Table 8) of female students from the control and female students from the experimental groups, indicated that there was statistically significant difference between the mean scores of the two groups. From the post-test conditions of the two groups; t(30) = −3.20, $p = 0.003 < 0.05$. Cohen's d value of 1.15 shows a large effect size between the two scores. This value shows that students in the experimental group performed better than those in the control group. This is in consonance with the findings of (Armah & Osafo-Apeanti, 2012; Mensah-Yawson, 2019)

Research Question 4: How do SHS students perceive the effectiveness of MalMath App integration in the learning of Mathematics?

The research question 4 was to find out how students perceive the effectiveness of the use of MalMath App in learning Quadratic Graph. Hence, students in the Experimental group were given questionnaires made up of 6 questions. Question 1 to 5 have options students to select from, (i.e. Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD)) and questions 6 Yes or No. Students were asked to rate how they perceived the effectiveness of the use of MalMath to learn properties of Quadratic Graph using the questionnaire. The results were analysed descriptively.

Table 9: Descriptive Statistics on how students perceive the usefulness MalMath App.

Experimental Group	N	No of students (SA)	No of students (A)	No of students (D)	No of students (SD)	Percentage of SA &A	Percentage of SD & D
Q1. MalMath App makes quadratic graph lessons more interesting	40	26	11	3	0	92.5	7.5
Q2. MalMath App makes quadratic graph lessons more practical	40	32	6	1	1	95	5
Q3. MalMath app makes quadratic graph lessons very easy to understand	40	27	8	5	0	97.5	2.5

Q4. Learning quadratic graph with MalMath App enhances graph visualization	40	25	12	3	0	92.5	7.5
Q5. MalMath App helps me to plot many graph within a short time.	40	30	9	1	0	97.5	2.5

The results from Table 9, shows that 92.5% of the students agreed or strongly agreed and 7.5% disagreed or strongly disagreed that MalMath App makes quadratic graph lessons more interesting, 95% agreed or strongly agreed and 5% disagreed or strongly disagreed that MalMath App makes quadratic graph lessons more practical, 97.5% agreed and strongly agreed and 2.5% disagreed and strongly disagreed that MalMath App makes quadratic graph lessons very easy to understand, 92.5% of the students agreed or strongly agreed and 7.5% disagreed or strongly disagreed that Learning quadratic graph with MalMath App enhances graph visualization and also 97.5% agreed or strongly agreed and 2.5% disagreed and agreed that MalMath App helps me to plot many graph within a short time. Therefore, most students have a positive perception of the effectiveness of the MalMath App to learn properties of quadratic graph. This result is in line with the findings of (Camilleri & Camilleri, 2020)

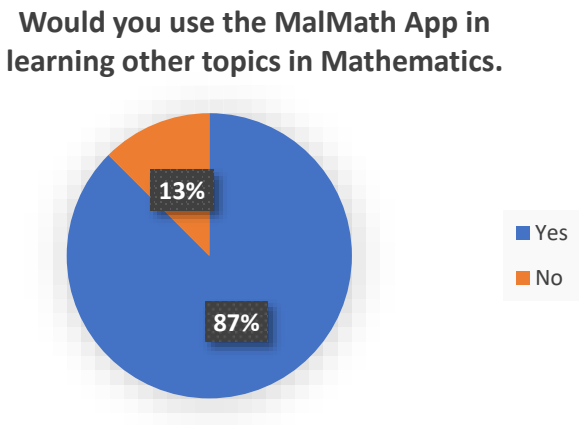

Figure 4: The number of students who would use the MalMath app in learning Mathematics

Figure 4, shows that 87% of the students said they would use the MalMath App in future topics in Mathematics and 13% responded they would not use the MalMath App in learning other topics in Mathematics. This indicated that students have formed positive perception towards the used of the MalMath Application software.

CONCLUSION

The study established the fact from the students that MalMath makes lesson more interesting, it makes mathematics lesson more practical, it enhances graph visualization and its interpretation and it helps the students reduce the turnaround time to plot graphs. According to the students, MalMath app helps them to grasp the meaning and identify properties of quadratic graph instead of memorization of these concepts. The study, therefore, concluded that MalMath is one of the solutions to the appalling performance in topics involving Graph works. Thus, if MalMath is introduced into the teaching and learning of Graphs, the students would easily understand the concepts since it promotes student-centred teaching and learning process.

RECOMMENDATIONS

The following recommendations are made based on the findings of this study:

1. Teachers should use MalMath App or related App to teach properties of quadratic graph. Since the integration of the App has help improved students' performance on properties of quadratic graph.
2. Teachers should not posit that male students perform better than their female colleagues do when it comes to the utilisation of MalMath App. The study showed that the male and female performance are at par.
3. Female students should be encourage to use MalMath App in their studies. This is because, this tool would help reduce, extraneous information by keeping them focused.
4. Students should be encourage and expose to the use of MalMath App, in order to arouse their interest in the study of properties of quadratic graph.

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