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The effect of technology integration on college of education students' achievement in quadratic equations: The perspective of photo math utilization

Prince Kusi [1*], Francis Ohene Boateng [2], Emmanuel Teku [1]

[1] Department of Mathematics and ICT, Berekum College of Education, Berekum, GHANA
[2] Department of Mathematics Education, Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development, GHANA

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Abstract

The study examined the usefulness of photo math app utilization in the teaching and learning of quadratic equations, the impact of photo math app usage on college of education students who were taught with photo math apps and those taught without photo math apps, and students' perceived challenges of using photo math apps in learning quadratic equations. The research paradigm was positivist with a quantitative approach and had survey and quasi-experimental as designs. A multi-staged sampling technique was used to select 200 respondents who were all first-year students from Berekum College of Education to participate in the study. Descriptive and inferential statistical analyses were performed using the statistical package for the social sciences package to examine the pre- and post-intervention data. Results revealed a significant increase in the usefulness of the photo math app in the teaching and learning of quadratic equations. The mean score on the impact of photo math app usage on college education students increased significantly from the pre-test to the post-test. The results of the t-tests further confirmed the effectiveness of photo math in enhancing students' achievement in mathematics, as it yielded a very high eta square statistic value. The findings of the study also revealed that there were some challenges with the usage of photo math technology. The study recommended that mathematics tutors at Berekum College of Education and other colleges of education incorporate mathematical apps and technological tools into their mathematics lessons in order to build the confidence and interest levels of their students and make their lessons very practical to improve their performance.

Keywords: achievement, algebra, photo math, technology integration, utilization

INTRODUCTION

Technological developments have completely changed the educational scene in recent years, especially in mathematics. The photo math app is one example of this innovation providing students with an interactive platform to use their smartphones to solve mathematical problems.

According to Seeland et al. (2024), mobile apps have developed into indispensable resources in educational environments over the last ten years. Because of its creative features and easy-to-use design, photo math which was introduced in 2014 has become very popular among pupils. The program lets users use the camera on their iPhone to scan mathematical equations, and it instantly displays graphs, explanations, and step-by-step answers. In higher education institutions like colleges of education, in particular, concerns have been raised concerning the influence of instantaneous solution accessibility on students' mathematical learning processes.

The impact of technology on education, namely in the field of mathematics, has garnered attention from scholars globally. The use of mobile applications in mathematics teaching has been examined by writers including Seeland et al. (2024) and Gyimah (2019), who have highlighted both the advantages and difficulties of doing so. Supporters contend that programs like photo math foster self-directed learning and problem-solving abilities, while detractors' express apprehensions over

✉ kusip.n@becoled.edu.gh **(*Correspondence)** ✉ foboateng@aamusted.edu.gh ✉ ekteku@becoled.edu.gh

Contribution to the literature

- The research proposed that photo math App has numerous advantages in teaching and learning of quadratic equations such as giving students the confortability to solve quadratic equations independently, increasing students' engagement and interest.
- The research revealed that photo math technology positively impacted the students' achievement in quadratic equations.
- The research proposed that students were fraught with some challenges about the usage of photo math technology.

the possibility of dependence, inadequate comprehension of concepts, and academic misconduct.

With its emphasis on teacher development and pedagogical techniques, the college of education provides an ideal environment for examining the effects of educational technologies on student learning outcomes. Gaining knowledge on how college of education students interact with and use the photo math application can help determine how effective it is as an additional teaching tool for mathematics. Furthermore, investigating the connection between future teachers' usage of technology and their academic achievement might help build curricula and instructional practices for teacher preparation programs.

Background to the Study

The potential for technology integration in educational settings to improve learning outcomes across a range of topics has attracted a lot of interest in recent years. Mathematics is one such discipline where interactive solutions to mathematical problems, including quadratic equations, are provided via technological tools such as photo math. In order to increase student engagement, comprehension, and achievement, technology integration in education refers to the use of electronic tools and resources in the teaching and learning process (Tsetsos & Prentzas, 2020). This integration can take many different forms, such as the use of interactive whiteboards or educational applications like photo math, which uses picture recognition technology to deliver step-by-step answers to mathematical problems.

A fundamental concept in mathematics education, especially in algebra lessons, is quadratic equations. Students who want to major in science, technology, engineering, or mathematics (STEM) need to be proficient in quadratic equations. However, because quadratic equations are so complicated, students frequently struggle to comprehend and solve them (López et al., 2016). As a technological tool, photo math provides a special technique for learning quadratic equations. photo math seeks to improve comprehension and problem-solving abilities by letting students use their cellphones or tablets to access detailed answers to problems. Additionally, students can receive rapid feedback through its interactive interface, which promotes self-directed learning and error correction (López et al., 2016). It is therefore crucial to know how technology integration, specifically the use of photo math, affects college teaching students' performance on quadratic equations in order to guide the development of curricula and instructional strategies in mathematics teaching. This study aims to examine how technological integration, in particular the use of photo math, affects college of education students' achievement in quadratic equations.

Statement of the Problem

Teaching and learning methods have been profoundly changed by the incorporation of technology into the classroom, especially in the subject of mathematics. There are concerns over the impact of mobile applications such as photo math, which provide students with immediate help in solving mathematical problems, on the mathematical performance of college of education students. Even while these kinds of apps are becoming more and more common, there is still a significant lack of study on their efficacy in higher education, especially in teacher preparation programs.

The potential advantages and difficulties of mobile applications in mathematics teaching have been examined in previous research by Seeland et al. (2024) and Gyimah (2019). Nevertheless, there is a study gap in our knowledge of the particular consequences of apps like photo math for college of education students because these studies mostly concentrate on K-12 education situations. Some studies indicate that integrating technology into the classroom can improve student learning outcomes and foster critical thinking abilities, while other studies raise issues regarding possible dependencies and the degradation of conceptual knowledge.

Furthermore, a deeper investigation of how technology affects future educators' learning experiences and pedagogical methods is necessary given the distinct setting of teacher preparation programs. It is crucial to comprehend how the photo math application affects the mathematical performance of college of education students in order to inform curriculum creation and instructional practices for teacher preparation programs. However, there is a dearth of systematic research on this topic, which leaves a vacuum

in the body of knowledge about the usefulness of mobile applications for teaching mathematics in higher education.

As a result, the issue this study attempts to solve is the necessity of examining how the photo math application affects the mathematical performance of college of education students in light of the particular circumstances surrounding teacher preparation programs. By addressing this knowledge vacuum, the project hopes to shed light on how technology might improve mathematics learning opportunities and guide teaching strategies in higher education environments.

Objectives of the Study

1. To assess the usefulness of photo math app in the teaching and learning of quadratic equations.
2. To determine the impact of photo math app usage on college of education students who are taught with photo math app and those taught without photo math app.
3. To find out students' perceived challenges of using photo math app in learning quadratic equations.

Research Questions

1. What are the usefulness of photo math app in the teaching and learning of quadratic equations?
2. What is the impact of photo math app on college of education who are taught with philomath app and those taught without photo math app.
3. What are the students' perceived challenges in using photo math app in learning quadratic equations?

LITERATURE REVIEW

The study hinged on three thematic areas namely; theoretical review, conceptual or empirical review, and the conceptual framework. The theories that underpinned the study included the cognitive load theory (CLT), technological acceptance model (TAM) and self-efficacy theory.

Cognitive Load Theory

According to Sweller's (1988) CLT, as cited by Kirschner et al. (2018), learning can be hampered when cognitive load surpasses the capacity of the human cognitive system. According to CLT, students who use the photo math program excessively and do not actively participate in problem-solving procedures may become cognitively overloaded. Teachers can create instructional techniques that maximize learning results while reducing cognitive load by understanding the cognitive demands involved with using photo math.

Technology Acceptance Model

This model, developed by Davis (1989) as it was also cited by Bertrand and Bouchard (2008), the TAM aims to explain why people embrace and utilize technology based on its perceived ease of use and utility. When it comes to the use of the photo math application, TAM indicates that college of education students' opinions about the app's usefulness and ease of use have an impact on their attitudes and actions toward it. The acceptability and adoption of photo math by students can be influenced by various factors, including the application's functioning, design of the user interface, and perceived advantages in enhancing mathematical comprehension. Teachers can find ways to support photo math's successful incorporation into mathematics instruction by looking at how students view the tool's utility and usability.

Self-Efficacy Theory

This theory also developed by Bandura (1977) asserts that people's motivation, conduct, and academic success are influenced by their perceptions of their own skills to carry out particular activities. This theory states that people who have high self-efficacy are more likely to persevere in the face of difficulties and put in more effort to reach their objectives. In the context of photo math, experiences with the program, such as their perceptions of their ability to use the technology on their own to solve mathematical problems, may have an impact on college of education students' self-efficacy beliefs.

Empirical Review

Impact of photo math usage on students performance

The effect of using the photo math app on students' learning results in mathematics has been examined in a number of research. For example, a study by Klinger and Walter (2022) investigated how mobile learning tools, such as photo math, could be integrated into the teaching of mathematics. He discovered that students' problem-solving abilities and mathematical comprehension improved when they utilized mobile applications like photo math.

Similar to this, Gyimah (2019) reviewed recent developments in the use of mobile applications in mathematics teaching, highlighting how these tools can improve student engagement and academic results.

Research suggests that adopting photo math in mathematics instructions may have a number of benefits. For example, Gyimah (2019) study found a positive relationship between students' use of photo math and their ability to conceptually understand mathematical ideas and solve problems. Similar findings were made by Seeland et al. (2024), who discovered that students who regularly used photo math in mathematics classes were more motivated and engaged. These

findings show that photo math can enhance student learning in college of education programs by acting as an adjunct to traditional teaching methods.

The study conducted by Zain et al. (2023) explored how photo math impacts student learning and engagement in mathematics. They found that students using the app showed improved problem-solving skills and a greater understanding of mathematical concepts.

Similar work done by Safiulina et al. (2024), also analyzed the role of photo math in supporting individualized learning in secondary education. They reported that the app facilitated personalized learning experiences and helped address diverse learning needs. This study was not different from the studies conducted by Soia (2022) who investigated the effectiveness of photo math as a supplementary educational tool in high school math classes. Their study indicated that the app could enhance students' problem-solving abilities and reduce math anxiety and LlenadaSantos (2022) who also examined the use of photo math in improving mathematics performance among college students. The research highlighted that the app contributed to increased student confidence and performance in algebra.

The usage of photo math in mathematics classes at the college of education was investigated by Garcia et al. (2020) in their study. They looked at how students' performance and academic integrity were affected by using the photo math software through a case study methodology. While some students found photo math to be a useful additional tool for checking their work, other students showed signs of dependence on the tool, which had a detrimental effect on their learning outcomes in mathematics. Concerns concerning the possibility of academic dishonesty were also expressed, since students may utilize the software to get answers without comprehending the underlying ideas (Bhise et al., 2022).

Challenges associated with the usage of photo math app

One of the main issues with using photo math is its technological limitations. Although photo math is great at identifying and solving mathematical expressions, it is not perfect. Research indicates that photo math can have trouble with handwritten or poorly scanned equations, which can result in incorrect solutions or misinterpretations (Klinger & Walter, 2022). Additionally, because the application relies on optical character recognition (OCR) technology, it can make mistakes when parsing complex mathematical notations or symbols (Cruciani, 2024). These technological limitations compromise the dependability and efficacy of photo math as a learning tool, particularly in situations where precise mathematical accuracy is essential.

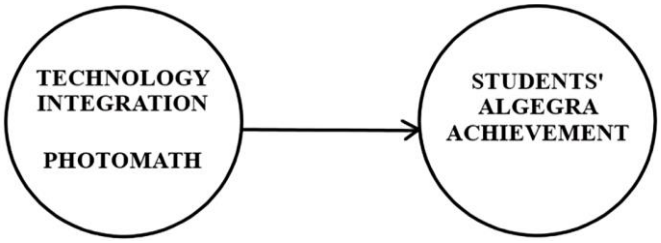

Figure 1. Conceptual framework (Source: Authors' own elaboration)

Beyond its technological drawbacks, photo math raises important ethical and educational concerns about how it affects student learning and academic integrity. Critics contend that photo math's convenience could encourage students to become less independent, which would lower their motivation to engage deeply with mathematical concepts and problem-solving techniques (Mathonsi, 2022). Additionally, the ease of access to immediate solutions through photo math could deter students from developing critical thinking and problem-solving skills, which would result in surface-level learning and a lack of conceptual understanding (Garcia, 2018). Educators are also concerned about the possibility that students could misuse photo math during assessments or exams, where they might turn to using the app on their cell phones to solve problems (Gaona et al., 2024).

Another challenge about the application of photo math is ethical implications**.** Using photo math brings up moral issues regarding intellectual property rights, privacy, and academic honesty. Due to photo math's instantaneous solution of mathematical problems, students could unintentionally submit work that violates academic integrity regulations by using it without giving sufficient credit or comprehension (Seeland et al., 2024). Furthermore, the techniques and solutions used by photo math may give rise to concerns about the moral sourcing and licensing of mathematical content, particularly when resources that are private or protected by copyright are involved (Clark, 2020). Additionally, privacy and data security are raised by photo math's gathering and processing of student data, especially in light of the storage and possible exploitation of sensitive data (Serdyukov, 2022). To guarantee the responsible and moral application of photo math in educational settings, it is imperative to address these ethical considerations.

Conceptual Framework

The conceptual framework for the study shows the effect that technology integration (photo math) have on students' algebra achievement in mathematics (**Figure 1**).

METHODOLOGY

Research Philosophy and Paradigm

The study adopted a positivist philosophical standpoint which contends that reality is independent and external which is open to objective measurement (Gannon et al., 2022; Plano Clark, 2017). The need of objective measurement and quantification in research is strongly emphasized by the positivist paradigm (Kankam, 2019). Adhering to this paradigm enables researchers to obtain precise and replicable outcomes by employing standardized instruments and methodologies for data collection (Creswell, 2021). Researchers who follow this paradigm seek to ensure the validity and reliability of their findings by carefully collecting and analyzing data in order to identify regularities and patterns in the natural world (Bryman, 2016). According to Kamal (2019), the aim of positivist research is to achieve generalizability, which involves deriving conclusions that may be applied outside the specific study situation. Statistical analysis combined with tight protocols allows researchers to infer patterns and trends that are reflective of bigger populations (Bryman, 2016).

Research Approach and Design

The quantitative research approach was employed to quantify the respondents' views and subject them to numerical measurement. Descriptive and quasi-experimental (nonequivalent groups) designs were both used in this study. The usefulness and difficulties in learning algebra (quadratic equations) before and after photo math's intervention were assessed using the descriptive design. Descriptive research, according to Cohen et al. (2020), is a study that illustrates and clarifies the characteristics of a group or phenomenon. Conversely, the quasi-experimental methodology was employed to ascertain the extent to which photo math improved students' algebra (quadratic equations) competence. In a nonequivalent groups design, researchers compare groups that are not randomly assigned. Typically, one group receives the treatment (intervention) while a comparison group does not. These groups are 'nonequivalent' because they might differ in important ways beyond the treatment (Rusticus & Lovato, 2011). Without employing random selection to split participants into groups, a quasi-experiment is an empirical study that looks at the cause-and-effect relationship of an intervention on a specific population (Creswell, 2021). The experimental (treatment) and control groups were composed of volunteers in accordance with the research design, which did not use a randomization process. Utilizing this method allowed the researchers to examine the reasons behind the effects of integrating the photo math app into teaching and learning in order to improve student performance (Creswell, 2021). Finding out how teaching quadratic equations to students at colleges using the photo math app affected their learning was the goal of the study. In that sense, lessons were planned and delivered to the students. The experimental group's (the students who used the photo math app) and control group's (the students who used the traditional approach, the marker-board method) were compared for education performance.

Population

The target population of the study was all first-year students of Berekum College of Education (excluding home economics students because they do not offer any mathematics course at this level) in the Bono Region of Ghana estimated to be 316 students made up of 174 males and 142 females. Students are put into three major groups upon admission into the college to read Bachelor of Education in early childhood, primary and junior high. These three major groups are further divided into seven smaller groups (classes) to make teaching and learning more effective.

Sample and Sampling Techniques

Sampling, according to Kusi et al. (2024), is the process of selecting a subset or the full population from a given sampling frame. The study employed proportional stratified sampling techniques to draw the samples from the respective classes to ensure equal representation. The sample size of 200 students was selected as recommended by Kusi et al. (2024).

To choose students for the sample size, we employed a lottery method of simple random sampling. The lottery method of simple random sampling was used to select the 200 respondents. In using the lottery method, a sampling frame made up of an alphabetical list of names of each student was used. The names indicated in the sampling frame were substituted with numbered cards such that each one corresponded to the name of the student. The cards were put in a box, mixed well enough, and randomly removed one by one without replacement. The number of any selected card was registered to match a student's name. This process was continued until the needed number of respondents was attained. The method was repeatedly used in all the selected classes to select 200 students who took part in the study. This was done to guarantee that every learner in every one of the chosen classes had a separate and equal chance of being chosen

A stratified sampling technique was used to determine the proportions of students from each stratum of classes to form the sample size. **Table 1** shows the proportion of the stratum summing up to the sample size.

Table 1. Sample size of the study (Field Data, 2024)

Classes	Number of students	Sample = (Stratum size/Accessible population) × Sample size
A	56	35
B	54	34
C	50	32
D	52	33
E	51	32
F	53	34
Total	316	200

Demographic Information of the Respondents

In all, 200 students participated in the study. This number comprised 113 males, representing 56.5%, and 87 females, representing 43.5%. The age distribution of students ranged between 16 and 19 years, 20 and 23 years, and 24 years and older, respectively 100, 85, and 15. These values accounted for 50.0%, 42.5%, and 7.5%, respectively. The participants also involved 51 Buchanan Hall, 50 Nicholas Hall, 49 Steward Hall, and 50 Yiadom Boakye students, which represented 25.5%, 25.0%, 24.5%, and 25.0%, respectively, of the total number of participants. **Table 2** shows that 100 (50.0%) students offered a Bachelor of Education (junior high school education) program, 56 (28.0%) students offered a Bachelor of Education (primary education) program, and 44 (22.0%) students offered a Bachelor of Education (early childhood education) program. Again, a total of one hundred and one questionnaires were distributed to the respondents in the experimental group, and all 101 questionnaires were retrieved from the respondents, representing a response rate of 100%.

Table 2. Demographic data of the respondents (Field Data, 2024)

Demographics	Frequency (N)	Percentage (%)
Gender	200	100
Male	113	56.5
Female	87	43.5
Age	200	100
16-19 years	100	50.0
20-23 years	85	42.6
24 years and above	15	7.5
Hall of affiliation	200	100
Buchanan	51	25.5
Nicholas	50	25.0
Steward	49	24.5
Yiadom Boakye	50	25.0
Program	200	100
BEd (junior high school education)	100	50.0
BEd (primary education)	56	28.0
BEd (early childhood education)	44	22.0

Data Collection Instruments

The quantitative data were collected using survey questionnaires and test (pre- and post-tests). Adapted questionnaires which have been fashioned in a Likert scale format from 1 strongly disagree through to 5 strongly agree was used to measure the constructs (Pekrun, 2011; Zimmerman, 2002). Changes in terms of wording were made to suit the local context. All scales were pre-tested to ascertain their validity and reliability.

Questionnaire

A questionnaire, according to Pinca (2023), is a list of inquiries sent to people in order to gather statistically valuable data about a particular subject or occurrence. They contended that every questionnaire should have a clear objective connected to the study's goals. In this study, students' views about the usefulness of photo math in learning quadratic equations, and students' perceived challenges in using photo math in the teaching and learning of quadratic at Berekum College of Education were gathered through a questionnaire.

The purpose of the research questionnaire was to gather views and data on students about the usefulness and challenges toward quadratic equations towards usage of photo math app. Students in the experimental group were the ones who received the questionnaire. Five-point Likert scale was utilized in the questionnaire. Given the five-point Likert scale, the average score is 3 ([1 + 2 + 3 + 4 + 5] ÷ 5 = 3). In this study, the determination of respondents' level of agreement with items in the questionnaires was done using mean and standard deviation such that mean < 3 indicated respondents' disagreement and mean > 3 also indicated respondents' agreement. Students' conceptual comprehension and capacity for problem-solving of the quadratic equation using photo math was the subject of the questions which sought information on their understanding. Students' perceived challenges with the photo math usage in the classroom was also captured on the questionnaire.

The questionnaire was used because it enabled the researchers to generate data specific to his research questions number one and three and also for easy comparisons. The questionnaire was again employed because it protected the privacy of the respondents as participants responded honestly to the questionnaire because their identity was hidden, and their confidentiality was also assured and maintained.

Pre- and Post-Test

Pre-test consisted of five questions of which students in both experimental and control groups were supposed to answer. The quadratic concepts and thoughts covered in the colleges of education's first-year curriculum were the basis for the pre-test questions. There were 10 total points available for the pre-test, with 2 points allocated for each question. The pre-test was used in the study to

Table 3. Reliability of questionnaire items leading to their construct (Field Data, 2024)

Construct	Number of items	Cronbach's alpha
Usefulness of photo math app in the teaching and learning	10	0.779
Students' perceived challenges of using photo math app	6	0.813

determine whether the background knowledge and comprehension levels of the students in the two groups were comparable enough to understand the idea of the quadratic equations. The researchers again administered ten questions on quadratic equation as a post-test to both the experimental and control groups after teaching the experimental group using photo math and the control group with the traditional or conventional method (marker-board method). Total marks allocated for the post-test was also 10 marks, 1 mark for each question. The main reason for conducting the post-test was to determine the treatment impacts and effects on the academic achievement of first-year students of Berekum College of Education. This test was conducted at the end of the treatment. The test was conducted under the supervision of the researchers and some colleague's mathematics tutors in the mathematics unit.

Intervention

The students were introduced to a photo math app, a type of technology tool that aided them to solve quadratic equations. Mathonsi (2022) discovered that students' problem-solving abilities and mathematical comprehension improved when they utilized mobile applications like photo math. The treatment group used a photo math app throughout their introduction, instruction, and practice of quadratic equations. This group was explicitly taught how the photo math app works, how to use the app and what it represents. Students used them during all work leading up to the post-test. The control group was denied access to a photo math app and continued with normal drills and practice with the use of worksheets and teacher-led instruction. A five-week experimental study was conducted on study participants. In weeks two through four, the intervention took place after the participants took a pre-test in week one. Since teachers were planning to teach the class for five weeks, this was done to avoid disrupting the regular schedule on the timetable. During those weeks, the experimental group was taught quadratic equations using photo math app, while the control group was not given access to use the app. During the fifth and final week, all participants took the post-test, which was different from the pre-test.

Validity and Reliability Evidence

All items leading to latent variables in the questionnaire were rated from 1 to 5 to assess the respondent's opinions. A Likert scale type questionnaire was adopted in the sense that its' psychometric scale was devised to measure and quantify the subjective preferential thinking and feelings of a subject through social interactions (Taherdoost, 2016). The validity of the questionnaires was assessed through the supervisor's judgment and also by allowing experts in the mathematics department at Berekum College of Education to look at the items in the questionnaire for their validity. These experts were employed to critically look at the content validity of the items to be convinced that the items are good to measure the construct under study. The reliability of the questionnaire items was established using a pre-test of respondents in another jurisdiction outside the study area (Alfarouq College of Education). The Cronbach's alpha of all Likert-type questionnaires from the pre-test was computed, and items with a Cronbach's alpha less than 0.7 were removed before commencing the study with the required questionnaires. Creswell (2021) opted that a Cronbach's alpha coefficient of 0.70 is considered reliable and a good indicator of internal consistency. The researchers adopted content validity index (CVI) which is the ratio of the number of experts rating the item as Essential to the total number of experts. Lawshe's CVI was calculated to determining the relevance of individual items in a scale that provides a broader evaluation of the entire instrument's content validity, ensuring that the scale as a whole accurately measures the construct. CVI also remains a fundamental tool in validating the content of measurement instruments. It provides a systematic approach to assessing whether an instrument covers the relevant content domain (Lawshe, 1975, cited by Surip et al., 2019). CVI of 0.70 or higher is often considered acceptable, indicating that a majority of the experts agree that the item is essential to the content area being measured.

Reliability Test

The researchers made use of two factors of 10 and 6 to assess the usefulness of photo math app in the teaching and learning of quadratic equations and to find out students' perceived challenges of using photo math app in learning quadratic equations. The reliability of Cronbach's alpha value for all the test items concerning the constructs sought to be determined is shown in **Table 3** after presenting the items to 25 respondents to assess the reliability of the questionnaires before embarking on the main study. The Cronbach's alpha of all the items is greater than 0.7, indicating their internal consistency. According to Wibaningrum and Aurellya (2020), a Cronbach's alpha coefficient on a scale of above 0.7 is desirable to measure construction in a study. **Table 3** shows the reliability of the questionnaires and the constructs they seek to measure.

Table 4. Descriptive statistics of the usefulness of photo math app in teaching and learning of quadratic equation (Field Data, 2024)

Variables	M	SD
I feel comfortable using the photo math app to solve quadratic equations independently.	4.3960	0.6177
The photo math app increases my engagement and interest in learning quadratic equations.	4.3168	0.7202
The photo math app helps me grasp the underlying concepts of quadratic equations better.	4.2772	0.6499
Using the photo math app saves me time when solving quadratic equations compared to manual method.	4.2574	0.7022
I feel more confident tackling challenging quadratic equations after using the photo math app.	4.2178	0.7695
The photo math app assists me in understanding the principles behind quadratic equation-solving techniques.	4.1881	0.6118
I believe the photo math app contributes positively to my academic performance in quadratic equations.	4.1683	0.8255
The photo math app simplifies complex quadratic equations effectively.	4.0990	0.7682
Using the photo math app motivates me to explore quadratic equations further.	4.0594	0.9573
The photo math app helps me check my work and verify solutions for quadratic equations.	4.0297	0.8883
Grand mean and standard deviation	4.2061	0.7511

Data Analysis and Approach

An introductory letter from the researchers' department was taken and sent to the authorities of Berekum College of Education to seek for permission upon which an appropriate date and time for the collection of data were discussed with the college authorities. Respondents were selected based on interest and ethical issues such as informed consent, confidentiality, and respect for human dignity of the respondents will be strictly adhered to. The questionnaire was administered personally and was taken back by the researchers. A total of one hundred and one questionnaires were distributed to level 100 students of Berekum College of Education who formed the experimental group. The number that formed the control group was ninety-nine. All 101 completed questionnaires were returned. For the tests, a five-week experimental study was conducted on study participants. In weeks two through four, the intervention took place after the participants took a pre-test in week one. Since teachers were planning to teach the class for five weeks, this was done to avoid disrupting the regular schedule on the timetable. During those weeks, the experimental group was taught quadratic equations using photo math app while the control group was not given access to photo math app. During the fifth and final week, all 200 participants took part in the post-test, which was different from but was similar to the pre-test.

The data taken from the field was edited, coded, and subjected to statistical analysis. The bio-data of the respondents was analyzed using descriptive statistics (frequencies and percentages) through statistical package for the social sciences version 25. Descriptive and inferential statistical analyses were performed to examine the usefulness, challenges and the pre-and post-intervention data about the photo math app usage. The mean and standard deviation were used in the data's descriptive analysis. Coefficient of variation (CV), which is the ratio of the standard deviation to the mean was calculated to determine the homogeneity and heterogeneity of the views expressed by the respondents. The paired sample t-test was additionally employed for inferential data analysis to draw conclusions from the data on the tests. Additionally, the effect that the treatment had on the experimental group was measured using the effect size test statistic (eta squared).

RESULTS

Research Question 1. What are the Usefulness of Photo Math App in the Teaching and Learning of Quadratic Equations?

To find out the usefulness of photo math app in teaching and learning of quadratic equations, the respondents were given a 5-point Likert scale to rate various items, 1 being the least and 5 being the highest. The means, standard deviations and the CV of respondents' responses were calculated for analysis purposes. With mean ranks, the responses were analyzed. **Table 4** displays descriptive analysis of the items measuring usefulness of photo math app in the teaching and learning of quadratic equations.

The results as depicted in **Table 4** revealed that, 'I feel comfortable using the photo math app to solve quadratic equations independently' was the highest ranked measure of the usefulness of photo math app in teaching and learning of quadratic equations. It secured a mean of 4.3960 and the standard deviation of 0.6177 indicating the most common opinion expressed by the respondents. The low standard deviation also indicates that the data points are closely clustered around the mean. The second ranked latent variable which obtained a mean of 4.3168 and the standard deviation of 0.7202 was 'the photo math app increases my engagement and interest in learning quadratic equations' which shows a strong view expressed by the respondents. The next higher rate measure was 'The photo math app helps me grasp the underlying concepts of quadratic equations better' with mean 4.2772 and the standard deviation of 0.6499 showing similar views shared by the respondents. The fourth rated latent variable was 'using the photo

Table 5. Wilcoxon signed rank test (Field Data, 2024)

Experimental group		N	Asymptotic sig. (2-tailed)
Post-test–pre-test	Negative rank	2	.000
	Positive rank	95	
	Ties	4	
	Total	101	

Table 6. Descriptive statistics for both pre- and post-test for the two groups (Field Data, 2024)

Test	Control group			Experimental group		
	N	M	SD	N	M	SD
Pre-test	99	2.8586	1.1868	101	2.6238	1.1212
Post-test	99	5.1313	1.1486	101	8.1188	1.4717

math app saves me time when solving quadratic equations compared to manual method' with mean 4.2574 and standard deviation of 0.7022 also indicate a common opinion expressed by the respondents. 'I feel more confident tackling challenging quadratic equations after using the photo math app' was the fifth rated measure by the respondents. It had a mean value of 4.2178 and the standard deviation of 0.7695. The sixth ranked latent variable was 'the photo math app assists me in understanding the principles behind quadratic equation-solving techniques' with mean 4.1881 and the standard deviation of 0.6118 indicating similar opinion shared by the respondents. 'I believe the photo math app contributes positively to my academic performance in quadratic equations' which obtained the mean of 4.1683 and the standard deviation of 0.8255 was rated higher than 'the photo math app simplifies complex quadratic equations effectively' with mean 4.0990 and the standard deviation of 0.7682. The nineth rated measure was 'using the photo math app motivates me to explore quadratic equations further'. It had a mean score of 4.0594 and the standard deviation of 0.9573. The least ranked latent variable which had a mean score of 4.0297 and the standard deviation of 0.8883 was 'the photo math app helps me check my work and verify solutions for quadratic equations' also showing similar responses by the respondents. In all, the usefulness of photo math app in teaching and learning of quadratic equations obtained a grand mean of **4.2061**, the corresponding grand standard deviation of **0.7511** and CV of **17.86%** which was less than **33%** which indicate a very strong homogeneity of views shared by the students that the use photo math app has a positive effect in teaching and learning of quadratic equations.

Research Question 2. What Is the Impact of Photo Math App on College of Education Who Are Taught With Philomath App and Those Taught Without Photo Math App.

A preliminary analysis of the data revealed that it did not meet the assumptions required for a parametric test. Consequently, a non-parametric test, specifically the Wilcoxon signed-rank test, was performed to ensure reliable conclusions. **Table 5** shows the results of the Wilcoxon signed-rank test, which was chosen due to the failure of the normality test. In **Table 5**, 95 students had higher scores on the post-test compared to the pre-test, as indicated by their positive ranks. Conversely, 2 students had higher scores on the pre-test than on the post-test, as shown by their negative ranks. Additionally, 4 students scored the same on both tests. The Wilcoxon test statistic, with a significance value of sig. = .000 < .05 (2-tailed), suggests that the observed difference between the pre- and post-test scores is statistically significant and likely due to the effectiveness of the intervention rather than random chance.

In an attempt to answer this research question, a quasi-experiment design was used with some classes selected as intact groups to constitute the experimental and control group, respectively to examine the impact that application of photo math app have on students' achievement in quadratic equations. The two groups, control and experimental, underwent pre- and post-testing to compare their baseline knowledge and achievement, respectively to determine the efficacy of the intervention. From **Table 6**, the spread of marks from the mean marks of both groups were not much different in the pre-test. The results in **Table 6** showed that the performance of pre-test of the control group (mean [M] = 2.859, standard deviation [SD] = 1.1868) was not statistically and significantly greater than the performance of pre-test of the experimental group (M = 2.6238, SD = 1.1212). The implication of the findings of the pre-test was that students in both groups had similar level of mathematics ability before the intervention, therefore, any differences in the performance of students in quadratic equations after the intervention was as a result of the intervention. However, in the post-test, the average performance between the control group (M = 5.1313, SD = 1.1486) and the experimental group (M = 8.1188, SD = 1.4717) was statistically significant.

A paired-samples t-test was conducted to evaluate the impact of the intervention. The paired samples t-test was used after the data was checked and satisfied the assumption of linearity, normality and absence of outliners. The results in **Table 6** and **Table 7** showed a significant increase in scores of the students from before the intervention (M = 2.6238, SD = 1.1212) to after the intervention (M = 8.1188, SD = 1.4717), t (100) = 30.252, p = .000 (two tail). With a 95% confidence interval of 5.1347to 5.8554, the mean increase in test scores was 5.4951. The large effect size is indicated by the eta square test statistic (.90).

Calculating the effect size for the paired sampled t-test

The researchers can confidently say that the interventions significantly changed the students' achievement based on the results in **Table 6** and **Table 7**. The results, however, do not reveal anything about how much of an impact the interventions had. To

Table 7. Paired samples test for the experimental group (Field Data, 2024)

	M	SD	Standard error mean	95% confidence interval		t	df	Sig. (2-tailed)	Eta square
				Lower	Upper				
Post-test–pre-test	5.4951	1.8255	.1816	5.1347	5.8554	30.2520	100	.000	.90

Table 8. Descriptive statistics of students' perceived challenges in using photo math app in learning quadratic equations (Field Data, 2024)

Variables	M	SD
Students without personal android phones cannot practice quadratic equations on their own using photo math app.	4.3960	0.5492
I experience frustration when the photo math app fails to recognize my handwritten in quadratic equations accurately.	4.2079	0.7255
I believe that using the photo math app for quadratic equations undermines the value of traditional pen-and-paper methods.	4.1386	0.6638
Lack of teaching and learning aids such as photo math by teachers makes it difficult for students to grasp the concept of quadratic equations.	4.0891	0.8012
Teaching and learning quadratic equations without the use of application software (photo math) made it difficult to understand the concept.	4.0198	0.9796
The photo math app does not support collaborative learning experiences for quadratic equations.	3.8020	0.9697
Grand mean and standard deviation	4.1089	0.7833

accomplish this, one method is to compute an effect size test statistic. One of the most widely used effect size statistics, eta squared, is calculated and interpreted, as follows:

$$Eta\ squared = \frac{t^2}{t^2+(N-1)} = \frac{(30.252)^2}{(30.252)^2+(101-1)} = .90,$$

where *t* refers to t-statistic shown in **Table 7**, *N* refers to the number of respondents provided in the **Table 5**.

The guidelines for interpreting this value are, as follows: .01 = small effect, .06 = moderate effect, and .7 = large effect as recommended by Kirk (2007). The researchers can infer from the calculated eta square's value of .90 that there was a significant effect because there was a significant difference between the test scores obtained before and after the intervention.

Research Question 3. What Are the Students' Perceived Challenges in Using Photo Math App in Learning Quadratic Equations?

Also, to determine the challenges faced by students in using the photo math app in learning quadratic equations, the respondents were asked to rate 5-point Likert scale items with 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = disagree, and 5 = strongly disagree. For analysis purposes, the mean and standard deviation of the responses given by the respondents were computed. These responses were analyzed with mean ranks. The results of the analysis are presented in **Table 8**.

The results in **Table 8** indicated that, 'students without personal android phones cannot practice quadratic equations on their own using photo math app' which secured a mean value of 4.3960 and the standard deviation of 0.5492 was rated very high by the students than all the latent variables on the challenges students faced in using photo math app in learning quadratic equations showing a very strong opinion expressed by the respondents. 'I experience frustration when the photo math app fails to recognize my handwritten in quadratic equations accurately' with mean 4.2079 with the standard deviation of 0.7255 was ranked higher by the respondents than 'I believe that using the photo math app for quadratic equations undermines the value of traditional pen-and-paper methods' which had a mean of 4.1386 and the standard deviation of 0.6638.

The fourth rated measure was 'lack of teaching and learning aids such as photo math by teachers makes it difficult for students to grasp the concept of quadratic equations. It obtained a mean of 4.0891 and the standard deviation of 0.8012. This means that respondents shared similar responses with this latent variable. 'Teaching and learning quadratic equations without the use of application software (photo math) made it difficult to understand the concept' was ranked fifth. The measure had a mean of 4.0198 and the standard deviation of 0.9796 also showing common opinion shared by the respondents. The least rated latent variable under this construct was 'the photo math app does not support collaborative learning experiences for quadratic equation' which secured a mean of 3.8020 and standard deviation of 0.9697 indicating common views shared by the respondents. It also indicates that the data points are closely clustered around the mean.

In all, students' ratings on challenges faced in using photo math app in learning quadratic equations yielded a grand mean of **4.1089** and the grand standard deviation of **0.7833.** the CV which is the measure of standard deviation was calculated and found to be **19.06%** which is again below **33%** confirming homogeneity of the opinions shared by the students that although photo math app has a lot of benefits in the teaching and learning of (mathematics), the app has some challenges

including 'students without personal android phones cannot practice quadratic equations on their own using photo math app, students expressing frustration when the photo math app fails to recognize their handwritten and teaching and learning quadratic equations without the use of application software such as photo math made it difficult for students understand the concept' were some views shared by the respondents that students experienced challenges in using photo math app in learning quadratic equations.

DISCUSSION

The study assessed the effect of technology integration on college education students' achievement in algebra: The perspective of photo math utilization. The specific objectives of the study were to; to assess the usefulness of photo math app in teaching and learning of quadratic equations, to determine the impact of photo math app usage on college of education students who are taught with photo math app and those taught without photo math app and to find out students' perceived challenges of using photo math app in learning quadratic equations.

It is believed that as a technological tool, photo math may influence the students' performance and achievement in algebra. The purpose of the first research question was to examine the usefulness of photo math app in the teaching and learning of quadratic equations. To get the students' opinions on the usefulness of photo math app in teaching and learning of quadratic equations, the construct was measured using 10 variables. The survey's results revealed.

Level 100 students of Berekum College of Education had a very consistent homogeneous opinion on usefulness of photo math app in teaching and learning of quadratic equations. This construct obtained a grand mean of 4.2061, the corresponding grand standard deviation of 0.7511 and CV of 17.86% which was less than 33% which indicate a very strong homogeneity of views shared by the students that the use photo math app has a positive effect in teaching and learning of quadratic equations. The results of the study also showed that the usage of photo math app helped students to solve quadratic equations independently, increases students' engagement and interest in learning quadratic equations, saves time when solving quadratic equations compared to manual method, builds students confidence thereby helping them to tackle challenging quadratic equations problems, help students to simplify complex quadratic equations effectively which at the long round contribute positively to academic performance of students. The study findings again show that photo math enhance student learning in college of education programs by acting as an adjunct to traditional teaching methods.

The findings of this study corroborate with the study done by Gyimah (2019). This study found a positive relationship between students' use of photo math and their ability to conceptually understand mathematical ideas and solve problems. The findings also support the study done by Zain et al. (2023), who explored how photo math impacts student learning and engagement in mathematics. They found that students using the app showed improved problem-solving skills and a greater understanding of mathematical concepts. The results of the study are in line with the work done by Safiulina et al. (2024), who analyzed the role of photo math in supporting individualized learning in secondary education. They reported that the app facilitated personalized learning experiences and helped address diverse learning needs.

Similar findings were made by Seeland et al. (2024), who discovered that students who regularly used photo math in mathematics classes were more motivated and engaged.

Additionally, the use of photo math app and how it affects students' performance in quadratic equations was the focus of the second research objective. The sample was analyzed using paired samples t-test to compare the means and the standard deviations of both pre- and post-test results for the students before the intervention and after the intervention for both control and the experimental groups. An examination of the group means in the pre-test indicates that the control group ($M = 2.8586$, $SD = 1.1868$) was a little bit higher than the experimental group ($M = 2.6238$, $SD = 1.1212$). This might be because of the student's educational background and algebraic prior knowledge of algebraic.

The experimental group post-test mean score was however 8.1188, an increase of 5.4951. This shows that on the post-test, every student in the experimental group scored higher. This increase in scores may be attributable to the use of photo math app in teaching and learning of quadratic equations. The statistical significance of the mean score difference between the experimental group's post-test and pre-test ($M = 5.4951$, $SD = 1.8255$) was also investigated using the paired sample t-test. This was carried out to assess how photo math technology affected students' algebraic achievement. From the results in **Table 6**, the student's performance improved statistically from the pre-test ($M = 2.6238$, $SD = 1.1212$) to the post-test ($M = 8.1188$, $SD = 1.4717$), $t(100) = 30.2520$, $p < 0.05$. The large effect size is indicated by the eta-squared statistics (.90).

This demonstrates that the usage of algebra tiles accounts for 90% of the variance in the scores, meaning that the experimental group's pre- and post-test were clarified by the instructional strategy (photo math technology) used to teach quadratic equations. The findings also show that the intervention had a significant impact on the students' performance, indicating that

they significantly improved their comprehension and mastery of the algebraic concept. Thus, using photo math app as a teaching tool or aid improved the students' algebraic achievement.

The pre- and post-test results for the experimental group showed a significant difference with a large effect size, indicating that the photo math app significantly improved the student's performance.

This result is consistent with studies conducted by Garcia et al. (2020). Their findings revealed that some students benefited from using photo math technology as a supplementary tool for checking their work. Also, the results were consistent with the TAM developed by Davis (1989). TAM indicates that college of education students' opinions about the photo math app's usefulness and ease of use have a great impact on students' attitude and action toward it, thereby enhancing their mathematical comprehension. The results again support the study done by LlenadaSantos (2022), who examined the use of photo math in improving mathematics performance among college students. The research highlighted that the app contributed to increased student confidence and performance in algebra. The findings are not different from the work done by Soia (2022). He investigated the effectiveness of photo math as a supplementary educational tool in high school math classes. Their study indicated that the app could enhance students' problem-solving abilities and reduce math anxiety.

Lastly, the third research objective was to determine the challenges associated with using the photo math app to learn quadratic equations. The perceived challenges with using the photo math app were also assessed using a questionnaire with six latent variables. The findings in **Table 7**, with a grand mean of 4.1089, a standard deviation of 0.7833, and a CV of 19.06% < 33%, demonstrated that strong and similar opinions were shared by the students when using the photo math app to learn quadratic equations. The survey results showed that there were challenges, notably 'students without personal Android phones cannot practice quadratic equations on their own using the photo math app', which hinders the usage of the photo math app in class. The findings of the study are not different from those discovered by Klinger and Walter (2022), who indicated that photo math can have problems with handwritten or poorly scanned equations, which can result in incorrect solutions or misinterpretations. Additionally, Cruciani (2024) revealed in their study that, because the application relies on OCR technology, it can make mistakes when parsing complex mathematical notations or symbols. Other critics contend that' photo math's convenience could encourage students to become less independent, which would lower their motivation to engage deeply with mathematical concepts and problem-solving techniques (Mathonsi, 2022).

CONCLUSION

The study assessed the effect of technology integration on college education students' achievement in algebra from the perspective of photo math utilization.

The results of the study showed that there were numerous advantages to the usage of the photo math app in the teaching and learning of quadratic equations, such as giving students the comfortability to solve quadratic equations independently, increasing students' engagement and interest in learning quadratic equations, making students more confident to tackle challenging quadratic equation problems, and above all, contributing positively to the academic performance of students in quadratic equations.

Similarly, the results of the study also revealed that photo math technology positively impacted the students' achievement in quadratic equations, as the findings of the post-test showed marked improvement in the students' achievement with a very high eta square statistic value of 0.90.

Again, it came to light that students were fraught with some challenges about the usage of photo math technology. The study's findings revealed that students without personal Android phones cannot practice quadratic equations on their own using the photo math app. Students experienced frustration when the photo math app failed to recognize their handwritten quadratic equations accurately.

It is therefore concluded that the advantages of using photo math technology in the teaching and learning of quadratic equations outweigh the challenges, and it has significantly improved the performance of students in quadratic equations.

Recommendation

According to the findings of the study, it is recommended that:

One, the photo math app increased students' engagement and interest in learning, developed their confidence level to tackle challenging quadratic equation problems, and increased their performance. It is therefore recommended that mathematics tutors at the Berekum College of Education and other colleges of education incorporate mathematical apps and technological tools in their mathematics lessons in order to build the confidence and interest levels of their students and make their lessons very practical to improve the performance of their learners.

Two, it is recommended that the college authorities in Berekum provide the necessary infrastructure and platforms that will support technology integration in mathematics teaching and learning. The Ghana Tertiary Education Commission should also emphasize more on the use of technology integration in mathematics

curricula for colleges of education in Ghana in order to prepare the students in the colleges to meet the demands of the 21st century.

Recommendations for Future Researchers

Future researchers should explore the integration of photo math in other mathematical concepts such as logarithm, indices, linear equations, sequence and series, calculus, and trigonometry, ensuring they serve as effective aids in learning and teaching of algebra.

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