Students' attitudes towards Photomath application in solving calculus problems using mobile camera

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***Abstract*- Photomath is a mobile application that simplifies mathematical problem-solving through capture images, detailed instructions, and a wide range of mathematical operations. It offers significant benefits for teachers and students. The aim of this study is to identify students' attitudes towards applying Photomath to solve calculus problems using a mobile phone camera at the College of Education - Benghazi, University of Benghazi. It also aims to reveal whether there are differences in their attitudes depending on the scientific specialization variable. To achieve the objectives of the study, the descriptive analytical method was used, and a stratified sample of (141) students was selected who enrolled in the department of Computer Science, Mathematics, and Physics at College of Education - Benghazi, during the fall semester of the academic year 2022/2023. To collect data, a questionnaire consisting of (20) items was constructed. The results of the study showed that the sample members' a high level of positive attitudes towards the use of the Photo math application for solving calculus problems through mobile camera were high. The results also showed that there are no significant differences between the three groups in terms of their attitudes towards the Photomath application.**

***Key words*: Attitudes, Photomath, educational technology, Calculus, mathematical problem solving.**

1 INTRODUCTION

Nowadays, mobile devices, such as smartphones, are extensively used by students both inside and outside the classroom. As a result, numerous studies have highlighted the positive effects of using mobile devices in mathematics learning. For example, research has shown that mobile devices were found to support the visualization of complex mathematical concepts, thereby enhancing students' understanding (Fabian, Topping, Barron, 2018). Additionally, the use of mobile devices has been associated with improved student performance in mathematics (Hwang, Lin, Ochirbat, Shih, Kumara, 2015, Sung, Chang, Liu, 2016, Etcuban, Pantinople, 2018).

The integration of mobile devices in mathematics education has proven to be beneficial in various ways. It has helped students understand graphs and discover new unfamiliar mathematical concepts, surpassing the traditional learning environment (Gupta, 2012). Additionally, students have shown positive attitudes towards mobile learning experience (Pollara and Brousard, 2011; Fabian & Topping, 2019; Su et al., 2020). A survey conducted among pre-calculus students revealed that (93%) of them acknowledged that the mobile app "made their lives easier" (Nguyen, Chen, 2016). Furthermore, a study conducted by Al-Takhyneh (2018) demonstrated that (80%) of students had positive attitudes towards using mobile applications. The study also indicated ascending scores in various areas: mathematical thinking (75%), achievement motivation (76%), developing social and emotional skills (77%), and application technology (96%).

Photomath is a mobile application that simplifies the process of solves mathematical problems by allowing users to capture images of texts, presenting solutions, and providing detailed instructions (Kelecsényi, Krauczi, & Zita, 2021). This powerful application is capable of handling basic operations involving powers, roots, fractions, decimals, and integers. It can also tackle more complex concepts such as systems of equations, quadratic and trigonometric expressions, exponents, and logarithms, as well as solving linear equations and inequalities. Furthermore, Photomath supports advanced mathematical operations like differential and integral calculus, complex numbers, and matrices (Kelecsényi, Krauczi, & Zita, 2021).

Photomath offers numerous benefits for both teachers and students. It enhances students' engagement in the learning process (Zakariashvili, 2021; Nurhayati, Roveruh, & Riski, 2021), increases their enthusiasm and ability to study mathematics, and improves their knowledge levels (Zakariashvili, 2021). Several studies have shown significant improvements in students' mathematics performance as a result of using Photomath (Saundarajan et al., 2020; Loregen, Amparo et al., 2022; Zakariashvili, 2021; Igcasama, Ramirez, Salanap, 2020; Amparo et al., 2022). Hartono's (2019) study revealed a positive response from students who used Photomath learning design, with an agreement rate of 85.83%. The study also showed an improvement in students' understanding of linear equations in two variables after using the Photomath learning design. Photomath has also been found to have positive effects on educational practices,

especially in teaching elementary algebra (Lin, 2007). Zakariashvili (2021) highlights that Photomath enables teachers to create a flexible learning environment, leading to increased collaboration between students, parents, and teachers. It has proven to be particularly beneficial for students who struggle with mathematics, resulting in improved academic performance.

Previous studies have consistently shown that students' attitude toward mathematics has a significant impact on their mathematics achievement (Chen et al., 2018; Dowker et al., 2019; Kiwanuka et al., 2020). Additionally, there is a well-established relationship between attitudes and learner performances (Mahanta, 2014; Mensah, Okyere, & Kuranchie, 2013; Mutodi & Ngirande, 2014). Attitude, in the context of this study, refers to "a predisposition or a tendency to respond positively or negatively to a certain idea, object, person, or situation or an attitude problem" (Mensah et al., 2013, p. 133). It is important to acknowledge that learner attitudes can be influenced by curriculum design, teaching practices, and school organization (Majeed et al., 2013). Therefore, students' attitude toward mathematics can be understood as their overall evaluation and perception of the subject (Hwang & Son, 2021).

Several studies have found a positive attitude toward the use of Photomath application (Klinger, 2018; Saundarajan, et al., 2020; Korenova, Veress-Bágyi, 2018). Additionally, teachers' have displayed positive attitudes towards Photomath, specifically regarding its use for solving mathematical problems using a mobile camera. It is worth noting that there were no statistically significant differences in teachers' attitudes towards Photomath based on their stage of teaching and teaching experience, however, differences in attitudes were observed based on teachers' educational qualifications, with those holding diploma degrees showing more positive attitudes (Iyad & Aslan, 2015). While Photomath offers numerous benefits, it also presents certain challenges and concerns that need to be addressed. One issue is the potential for cheating in homework and exams when utilizing Photomath (Cox, 2020). Furthermore, the available version of Photomath sometimes provides lengthy algorithmic solutions (Webel & Otten, 2015). Another limitation is that the mobile application is unable to graph multiple functions in the same coordinate system, as noted by Klinger and Schüler (2018). Additionally, there is a risk of students losing interest in independently completing their homework when relying on the Photomath method, potentially leading to laziness (Zakariashvili, 2021).Moreover, the use of Photomath has been found to alter students' mathematical behavior, as they are more likely to question their results, constantly check their solutions, and interpret the answers (Kelecsényi, Krauczi, & Zita, 2021).

However, there is limited research in mathematics education in Libya highlighting the use of mobile applications and associated pedagogies. This study, conducted at the Faculty of Education - Benghazi, University of Benghazi, is the first of its kind in local context. Given the proliferation of devices and applications, it is important for educators to assess their effectiveness in supporting student learning, especially in mathematics. The study focuses on the implementation of the Photomath application in Mathematics I and II, which are fundamental calculus courses offered to students majoring in physics, computer science, and mathematics at the Faculty of Education - Benghazi, University of Benghazi. Mathematics I covers key mathematical concepts such as the real number system, functions, limits, and derivatives. Mathematics II concentrates on the application of derivatives and integrals. Therefore, the objective of this study is to investigate students' attitudes toward the Photomath application for solving calculus problems using a mobile camera at the Faculty of Education - Benghazi, University of Benghazi.

2 THE STUDY QUESTIONS

1. What are students' evaluation regarding Photomath for solving calculus problems using a mobile camera at the Faculty of Education - Benghazi, University of Benghazi?
2. What are students' attitudes towards Photo math application in solving calculus problems using mobile camera?
3. Are there statistically significant differences at the significance level ($\alpha \geq 0.05$) between the means of students' attitudes towards Photomath application in solving calculus problems using mobile camera towards due to the scientific specialization variable?

3 THE STUDY ASSUMPTION

The following hypothesis emerged from the study questions: There are no statistically significant differences at the significance level ($\alpha \geq 0.05$) between the means of students' attitudes towards Photomath application in solving calculus problems using mobile camera towards due to the scientific specialization variable.

4 SIGNIFICANCE OF THE STUDY

This study makes significant contributions to mathematics education by addressing research gap and providing practical perspectives and recommendations. This represents the first investigation of its kind at the local level, specifically focusing on the integrating of the Photomath application into calculus instruction into teaching and learning. This study examined the attitudes of students at Benghazi College of Education towards using Photomath to solve calculus problems using their mobile phone cameras. This research sheds light on the practical implications and challenges associated with integrating such technologies into teaching practices. Moreover, the findings of this study

add to the existing literature on the integration of modern technologies in mathematics education, specifically in Libya. These findings can inform educators and policymakers about ways to develop evidence-based strategies to enhance mathematics learning and improve student engagement and outcomes. Furthermore, this study provides practical recommendations for educators and policy makers on effectively integrating Photomath and similar technologies into mathematics education to enhance teaching practices, improve student experiences, and improve educational outcomes in mathematics. These evidence-based recommendations can guide teachers in designing educational curricula that leverage the benefits of technology, foster a dynamic learning environment, and enhance students' problem-solving skills. Policy makers can benefit from these recommendations to develop guidelines, allocate resources, and support the implementation of technology-enhanced learning strategies. This is in line with Benghazi University guidelines that encourage teachers to take advantage of technology.

5 STUDY OBJECTIVES

This study aims to:

1. Knowing students' evaluation regarding Photomath for solving calculus problems using a mobile camera at the Faculty of Education - Benghazi, University of Benghazi.
2. Knowing students' attitudes towards Photomath application in solving calculus problems using mobile camera.
3. Detecting whether there are statistically significant differences at the significance level ($\alpha \geq 0.05$) between the means of students' attitudes towards Photomath application in solving calculus problems using mobile camera towards due to the scientific specialization variable.

6 DELIMITATIONS OF THE STUDY

– Objective limitations: The scope of this study was restricted to examining students' attitudes toward the utilization of the Photomath application for solving arithmetic problems using a mobile camera.
– Human limits: The participants in this study were selected from the Department of Mathematics, Physics, and Computer at the College of Benghazi Education, University of Benghazi.
– Spatial boundaries: The study was conducted at the College of Benghazi Education, University of Benghazi.
– Time limits: Data collection for this study took place during the fall semester of the academic year 2022/2023.

7 TERMINOLOGY OF THE STUDY

– **Attitudes** is a tendency to react in a positive or negative style with respect to a given attitude object Oskamp and Schultz's (2005). The researcher defined it as the responses of the study sample with acceptance or rejection to the items of the scale prepared by the researcher
– **Photomath application**. A digital application for a smart device providing solutions to math problems. The student takes a picture of the problem, then the solution appears (Webel & Otten, 2015). The application recognizes equations of both printed and handwritten and provides step-by-step calculations and graphical solutions.
– **calculus problems:** Calculus is one of the areas of mathematics that deals mostly with the basic concepts of mathematics, such as Real Number Systems, Functions, Limit, Derivatives, and Integral (A. F, 2015).

8 METHODOLOGY

The descriptive analytical approach was adopted

8.1 The study population and sample:

The study population of interest consisted of all (220) students enrolled in the Department of Computer Science, Mathematics, and Physics at the College of Education, University of Benghazi, during the fall semester of the academic year 2022/2023. The study sample consisted of (141) male and female students, representing approximately (64%) of the total study population. The study sample was selected using a stratified random sampling method from the study population. The study sample members were then distributed according to the demographic variables, as presented in (Table 1).

Table (1) the study population and sample

Variables	Variable level	Population	Sample	
			%	N
Specialization	Computer	102	46.1	65
	Mathematics	88	39.7	56
	Physics	30	14.2	20
Sum		220	100	141

8.2 Instrument

To achieve the objectives of the study, a questionnaire was developed based on a comprehensive review of the literature. The questionnaire consisted of two sections: The first section collected information about the students' specialization and sought their evaluation of learning through the Photomath program. The second section included (28) items designed to measure students' attitudes toward photomatath. The initial version of the questionnaire was reviewed by experienced professionals who provided feedback for necessary modifications and deletions. Through this process, the final version of the questionnaire was improved to include (25) items. Each item in the questionnaire asks students to indicate their point of view on a three-point Likert scale (agree, somewhat agree, disagree) by checking the corresponding box. Table (2) shows the classification of levels of agreement and their corresponding numerical values. Positive items are assigned values of 3, 2, and 1, respectively, while negative items are assigned the same values in reverse order.

Table (2) Three-point Likert scale

Agree	*agree to some extent*	*Disagree*
3	*2*	*1*

To facilitate the statistical analysis, the questionnaire consists of (25) items was administered to a separate survey sample of (30) students who were not included in the main sample. After confirming the stability and reliability of the study tool based on the feedback received from this exploratory sample, the questionnaire was refined and improved. The final version of the questionnaire consisted of (20) items, which were then distributed to the main sample for data collection and analysis.

8.3 Face validity of the study instrument

To ensure the validity of the study tool, the initial version of the questionnaire was presented to total of (10) experienced and competent faculty members from the University of Benghazi. They were asked to express their opinions regarding the clarity of the paragraphs, the accuracy of the language used, and the suitability of the paragraphs in measuring the aim of the study. The comments and recommendations provided by the reviewers have been carefully considered and included. Based on this review process, the paragraphs that received majority approval from the reviewers were retained, while the remaining paragraphs were subject to revisions, reformulation, deletions, or new additions. Through this process, the initial version of the questionnaire was modified and revised. As a result, the final version of the questionnaire consisted of 25 items.

8.4 Internal consistency

The data reveals a strong level of internal consistency for most of the values, indicating a high degree of agreement among these items. However, there are specific items, such as items 1, 5, 14, 16, and 25, where the internal consistency is weak. As shown in (Table 3).

Table (3) Correlation Coefficients with (25) items

students' attitudes towards Photo math application in solving calculus problems									
Paragraph	correlation coefficients	Paragraph	correlation coefficients	Paragraph	correlation coefficients	Paragraph	correlation coefficients	Paragraph	correlation coefficients
(1)	.288	(6)	.542**	(11)	.456*	(16)	.313	(21)	.738**
(2)	.637**	(7)	.739**	(12)	.668**	(17)	.410*	(22)	.413*
(3)	.493**	(8)	.815**	(13)	.478**	(18)	.526**	(23)	.705**
(4)	.442*	(9)	.657**	(14)	.018	(19)	.505**	(24)	.455*
(5)	.275	(10)	.677**	(15)	.566**	(20)	.431*	(25)	.321

Correlation is significant at the 0.05 level (2-tailed).*
Correlation is significant at the 0.01 level (2-tailed). **

As a result, the weak items 1, 5, 14, 16, and 25 were excluded from the questionnaire to ensure overall reliability of the result as shown in (Table 4).

Table (4) Correlation Coefficients with (20) items

students' attitudes towards Photo math application in solving calculus problems							
Paragraph	correlation coefficients	Paragraph	correlation coefficients	Paragraph	correlation coefficients	Paragraph	correlation coefficients
(1)	.666**	(6)	.821**	(11)	.421*	(16)	.428*
(2)	.566**	(7)	.741**	(12)	.556**	(17)	.760**
(3)	.507**	(8)	.705**	(13)	.453*	(18)	.361*

(4)	.587**	(9)	.536**	(14)	.448*	(19)	.703**
(5)	.793**	(10)	.677**	(15)	.482**	(20)	.404*

Correlation is significant at the 0.05 level (2-tailed).*
Correlation is significant at the 0.01 level (2-tailed). **

8.5 The reliability of the study instrument

Reliability analysis was conducted to assess the consistency of the study tool, using Cronbach's alpha coefficient. The study tool was administered to a sample of (30) students in the academic year 2022/2023. The Cronbach's alpha coefficient was calculated as (0.895), indicating a high level of internal consistency among the (20) items included in the study, which is considered acceptable for the purpose of the study.

8.6 Study variables

This study deals with the independent and dependent variables, which are as follows:

– The independent variables, which were represented in the scientific specialization of students, which are (mathematics, computer and physics).

– The dependent variables, or the measured variables, represented in: Students' attitudes towards Photomath application in solving calculus problems using mobile camera.

8.7 Statistical Analysis

To achieve the objectives of the study, data were analyzed using Statistical Package for Social Sciences (SPSS), and the following statistical methods were used

– The Alpha- Cronbach coefficient was used to verify the stability of the study scales.

– The arithmetic means and standard deviations of respondents were computed the first research question

– One-Way ANOVA was used to reveal the presence of statistically significant differences at the significance level ($\alpha \geq 0.05$) between the means of students' attitudes towards Photomath application in solving calculus problems using mobile camera towards due to the scientific specialization variable at the College of Education University of Benghazi.

8.8 Classification of responses

The standard values that were adopted in this study to determine the level of responses from the study sample perspective are shown in a (Table 5). These values act as criteria to classifying responses into different levels, such as high, moderate, or low, based on the mean scores.

Table (5) Standard to determine the level of responses

Response Level	*High*	*Moderate*	*Low*
Mean Score	*2.34-3*	*1.67-2.33*	*1-1.66*

9 STUDY RESULTS

1) Results related to the first question **"What are students' evaluation regarding Photomath for solving calculus *problems using a mobile camera* at the Faculty of Education - Benghazi, University of Benghazi?"**

Table (6) student's evaluation of Photomath.

Statement	*N*	*%*
Excellent	*37*	*26.2*
Very Good	*75*	*53.2*
Good	*29*	*20.6*
Total	*141*	*100.0*

Table (6) shows the frequency and percentage of student ratings regarding their evaluation of Photomath. The results showed that the majority of students (79.4%) rated Photomath as either “very good” or “excellent.” This indicates that a large proportion of the sample views Photomath positively. In addition, 20.6% of students rated it “good”, indicating an overall positive evaluation.

2) Results related to the second question: What is the level of students' attitudes towards Photo math application in solving calculus problems using mobile camera?

To answer this question, the arithmetic means, standard deviations, and ranks were calculated for the items on students' attitudes towards Photo math application in solving calculus problems using mobile camera, and Table (7) shows this.

Table (7) students' attitudes towards Photo math application in solving calculus problems

NO	Statements about Photo maths application	Mean	Std. Deviation	Estimation
1.	I believe that the Photomaths is a tool for learning, gaining information, and exploring different methods of solving mathematical problems.	2.70	.570	High
2.	Photomaths allows me to complete learning activities more quickly	2.66	.583	High
3.	I believe that having Photo maths on my phone will enhance my	2.60	.609	High

	performance			
4.	I believe that solving math problems using the Photo math app will improve academic achievement	2.41	.757	High
5.	I believe that the Photomath solves problems with simple and easy steps.	2.48	.682	High
6.	I believe that using the Photomath app has given me a greater opportunity to understand and comprehend different math problems	2.42	.678	High
7.	I found it helpful to learn how to solve math problems using the Photomath with the correct step-by-step solutions.	2.60	.642	High
8.	I think the Photomath will help overcome the difficulties I face in solving different math problems.	2.61	.630	High
9.	Using the Photomaths helps in performing mathematical tasks and successfully solving the required assignments	2.72	.522	High
10.	I think Photo maths is an important tool for problem-solving during distance education.	2.64	.636	High
11.	I believe that individual differences between students will disappear when using the Photomath in the classroom.	2.13	.758	Moderate
12.	I think Photomath app should be included in classroom teaching.	2.45	.701	High
13.	I believe that Photomath eliminates the worry of not knowing the solution.	2.55	.681	High
14.	Photo math app helps raise motivation for learning.	2.46	.692	High
15.	Photomaths helps in self-learning as a guide for solving various mathematical problems	2.65	.575	High
16.	I like to use Photomaths to verify the solution because I trust its results	2.62	.581	High
17.	I enjoy seeing the steps to solve mathematical problems by pointing the handheld camera at the printed problem.	2.56	.669	High
18.	I enjoy using different technological applications for smart devices in learning mathematics.	2.62	.627	High
19.	Photomaths encourages communication with peers in explaining some solution steps.	2.58	.645	High
20.	I enjoy participating in discussions about various technological applications for smart devices related to solving math problems.	2.51	.683	High
Sum		2.55	0.306	High

The results presented in Table (3) show that students expressed a high level of positive attitudes towards the use of the Photo math application for solving calculus problems through mobile camera. The arithmetic mean of (2.55) and a standard deviation of (0.306) indicate that participants generally had positive perceptions of the Photomath application and acknowledged its positive impact on their learning experience. In particular, Item (1) received the highest mean score, suggesting that participants perceive the Photomath application as a valuable tool for learning and exploring various methods of solving mathematical problems. However, item (11) received a moderate mean score, indicating that participants had a more neutral attitude towards the belief that individual differences between students disappear when Photomath is used in the classroom. Overall, these findings reinforce the positive attitudes of students towards the Photomath app and highlight its potential as an effective tool for learning and problem-solving in the context of calculus. The researcher can attribute this result to the user-friendly of the application, which allows students to capture images of text, submit solutions, and receive detailed instructions, fosters their inclination to utilize and benefits derive from the tool. Another reason could be the teaching style of the instructor with proper support and guidance on how to use the application to check the mathematical problems. These findings align with previous studies conducted by Klinger (2018), Sundararajan et al. (2020), and Korenova and Ferris Baige (2018).

To ensure the normal distribution of the data, the data was examined by performing two tests (Kolmogorov-Smirnov, Shapiro-Wilk). Table (8) shows that the Kolmogorov-Smirnov test yielded a statistic of (0.292) with a significance level of (0.000) and the Shapiro-Wilk test yielded a statistic of (0.771) with a significance level of (0.000). The results indicate that the distribution of the data is not normal. Therefore, the researcher will resort to using parametric tests in inferential statistics to answer the study hypothesis.

Table (8) Tests of Normality

variable	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
specialization	.292	141	.000	.771	141	.000

3) ***Results of testing the study hypotheses: There are no statistically significant differences at the significance level (α ≥ 0.05) between the means of students' attitudes towards Photomath application in solving calculus problems using mobile camera towards due to the scientific specialization variable.***

The Kruskal-Wallis test was employed to test the null hypothesis, considering the non-normal distribution of the data.

Table (9) Kruskal Wallis Test

Specialization	N	Mean	Median	Chi-Square	df	Sig.
physics	20	86.38	2.6500	3.426	2	.180
mathematics	56	69.79	2.6000			
Computer	65	67.31	2.5500			

Table (9) shows that the Chi-Square statistic for the Kruskal-Wallis test is (3.426) with (2) degrees of freedom (df). The associated asymptotic significance (p-value) is (0.180).This indicates there are no statistically significant differences at the significance level (α ≥ 0.05) between the means of students' attitudes towards Photomath application in solving calculus problems using mobile camera towards due to the scientific specialization variable. Therefore, we accept the null hypothesis, indicating that there are no significant differences between the three groups in terms of their attitudes towards the Photomath application. The researcher attributes this to the unified teaching approach across the different groups. The lecturer may use a similar teaching method for all groups when presenting the course material, leading to similar attitudes towards the use of Photomath in the curriculum. Moreover, the ease of the application and its availability on students' smartphones may contribute to their benefit from the Photomath program for all scientific disciplines.

10 RECOMMENDATION

The study recommended taking advantage of modern technologies and smart devices available to students and harnessing them to serve the educational process. Furthermore, researcher is encouraged to conduct a study integrating Photomath into the classroom activities in a bigger population and wider scope.

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