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Photomath application for learning algebra: Preliminary study on a school in border area

Meiva Marthaulina Lestari Siahaan[1*], Cecilia Novianti Salsinha[2], Lailin Hijriani[3], Selestina Nahak[4], Farida Daniel[5]

[1,2,3,4]Department of Mathematics Education, Faculty of Teacher Training and Education, Universitas Timor, Kefamenanu, Indonesia

[5]Department of Mathematics Education, Faculty of Teacher Training and Education, Institut Pendidikan Soe, Soe, Indonesia

*Corresponding author: meivamarthaulina@gmail.com

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ABSTRACT

This research was motivated by the shift in the educational paradigm toward technology-integrated learning and addresses the disparity in facilities between urban and border area schools. It aimed to determine the effect of Photomath on students' cognitive abilities and to assess their attitudes, motivation, belief, and readiness towards its use in a border area school. The instruments employed were pretest, posttest, and questionnaire. This research serves as an initial study on the use of technology in schools located in border areas. A mixed-method approach was employed, combining qualitative and quantitative analyses. The qualitative analysis of student responses was facilitated by Photomath, while the quantitative method followed a pre-experimental one-group pretest-posttest design. The findings showed a 36.25% improvement in algebra test scores. Students' learning motivation reached 82.97% (very strong), belief in Photomath was 88.13% (very strong), and readiness to use the Photomath was 78.97% (strong). After using Photomath, students understood each stage of solving algebra problems better, indicating that Photomath supported their learning process. The implication is that integrating Photomath in border-area schools provides valuable support for students, particularly in self-directed learning.

Aplikasi Photomath dalam pembelajaran aljabar: Studi awal pada sekolah di perbatasan

Kata Kunci:

aljabar, aplikasi, kawasan perbatasan, Photomath, teknologi

ABSTRAK

Penelitian ini didasarkan pada perubahan paradigma pendidikan menuju pembelajaran yang terintegrasi teknologi, serta memperhatikan kesenjangan fasilitas antara sekolah di daerah perkotaan dan daerah perbatasan. Tujuan dari penelitian ini adalah untuk mengetahui pengaruh penggunaan Photomath terhadap kemampuan kognitif siswa dan menilai sikap siswa—motivasi, kepercayaan, dan kesiapan—dalam menggunakan Photomath di sekolah wilayah perbatasan. Instrumen yang digunakan meliputi pretest, posttest, dan kuesioner. Penelitian ini juga merupakan studi awal mengenai penggunaan teknologi di sekolah daerah perbatasan. Pendekatan mixed-method digunakan: analisis kualitatif terhadap jawaban siswa dibantu dengan Photomath, sedangkan metode kuantitatif menggunakan desain pre-eksperimental dengan pretest-posttest satu kelompok. Hasil penelitian menunjukkan peningkatan skor tes aljabar sebesar

36,25%. Motivasi belajar siswa mencapai 82,97% (sangat kuat), kepercayaan terhadap Photomath sebesar 88,13% (sangat kuat), dan kesiapan menggunakan Photomath sebesar 78,97% (kuat). Setelah menggunakan Photomath, siswa lebih memahami setiap tahapan dalam menyelesaikan soal aljabar, yang menunjukkan bahwa Photomath mendukung proses belajar mereka. Implikasi dari penelitian ini adalah bahwa penggunaan Photomath di sekolah perbatasan memberikan manfaat yang signifikan bagi siswa, terutama dalam pembelajaran mandiri.

Contribution to the literature

This research contributes to:

- Advancing the algebra learning using Photomath that could be used anywhere and could be downloaded in smartphone.
- Performing the findings regarding students' motivation, belief, and readiness to use Photomath in border area schools.
- Recommending Photomath technology to support student's independent learning and confidence to solve algebra tasks.

1. INTRODUCTION

Technological advances have substantially changed the way mathematics is taught and studied. The advances may reflect positively on student engagement in learning mathematics. Emata[1], and Romero and Angeles [2] state that technology may cause students to develop poor attitudes towards learning mathematics, like decreased learning persistence because of the convenience offered by the technology. Therefore, some studies emphasize to monitor students' attitudes toward mathematics and their learning with technology [1]–[5]. The researchers argue that investigating the attitudinal factors associated with the use of technology in mathematics in developing country (Indonesia), where access to technology is still seen as a symbol of modernity, deserves special attention. It is even more important to consider students' attitudes in developing countries as a key component that must be taken into account to ensure a smooth mathematics learning process. In addition, students have own preferences regarding the kind of learning source to support their study [6].

The problem faced by junior high school students is that they have difficulty in solving algebraic problems procedurally and manipulating algebraic forms to produce a solution or achieve an equation [7], [8]. In other words, a mathematical fluency ability is needed in carrying out algebraic procedures [9] and can be obtained from repeated practices. Initially, students try to solve an algebra problem, but if they reach a dead end and do not find an alternative solution, the calculating or processing to find the solution is stopped. The mathematical fluency ability may not be formed if this situation continues to occur. The situation could be worst in case the students do not find any mentor or someone that they entrusted to help them for solving the algebra problem [10]. Students are usually given routine problems so that they can work fluently. However, during practice sessions, the problems will vary in difficulty. In general, the problems faced by students in learning algebra material are the same between students in urban areas and in border areas.

According to these facts, they need a tool or media that accompanies and helps them in solving difficult problems. The media can help them to get used to dealing with various levels of difficulty of questions [11]. The students need the tool that espouse and direct them to the correct answer steps. One of the technology that fit to this student need is

Photomath. Photomath includes a feature for detecting mathematical symbols. It is an application available on Android, iOS, and Windows phones that allows users to solve math problems by either taking a photo or manually inputting the problem. The app then provides step-by-step solutions to guide users through the solving process [12], [13]. The Photomath is an application used to help solve mathematical problems related to division, roots and powers, decimal squares, basic arithmetic, and simple linear equations [14].

The veritable and comprehensive mathematics application makes it easier for students to concretize symbols, tabulate, and complete mathematical calculations. One application that can be used is the Photomath application [15]. The Photomath application can assist understudies who have trouble understanding algebra problems rapidly, for all intents and purposes and can be utilized for simple and complex questions [16]. Photomath can be downloaded from the App Store for iOS or the Play Store for Android. To use the application effectively, students should write math problems clearly and neatly on paper to ensure accurate recognition. Once the problem is written, they can take a photo using the app, which then generates the solution along with step-by-step explanations. Since Photomath cannot accurately process unclear or messy handwriting, it encourages students to develop clearer and more organized writing habits.

Photomath offers various advantages and benefits for students. They can study on their own because they simply need to write the questions precisely and neatly on paper and then take images [17]. After the results and how to solve the questions come out, students can copy them into the book and at the same time understand the steps listed in the Photomath application [18]. Using the Photomath application can also be useful for students in correcting questions answered manually. Simply put, the Photomath application supports students' independent learning attitudes and can motivate them to work on difficult types of problems in mathematics [19].

Knowing the fact that technology has positive impact for improving the quality of teaching and learning inline with the use of technology in learning is commonplace in big cities [20]. This situation is supported by a good Internet connection, adequate device ownership, and qualified human resource knowledge in using technology. The use of technology becomes a challenge in itself if used in border areas. The challenges faced are a person's acceptance of using technology, a person's willingness to learn technology, and an understanding of the technology itself [21]. In fact, technology is here to help someone to make their work easier. In the context of mathematics learning, students are assisted by the Photomath application to guide them in finding the steps used to complete a calculation operation. Photomath is efficient because the time used in classroom learning is limited and gives teachers space to pay attention to students who are still lacking in independent learning.

Previous studies have explored the benefits of Photomath as a tool for distant learning in teaching algebra [22], Photomath as a tool for helping students to improve mathematical achievement [23], Photomath as a tool for online learning [24], Photomath as a tool in design learning [25], and mathematics teachers’ attitude towards Photomath. However, these studies focus on the use of Photomath and the attitude from mathematics teachers. The studies do not reveal the students’ attitude, like motivation, belief, and readiness to use Photomath, especially for students in border areas.

Several researchers have focused on the use of technology in schools located in urban areas, where students are well-equipped with technological tools and accustomed to using them. However, limited studies have explored the use of technology in schools in border areas, where students have restricted access to technological facilities and infrequently use digital tools. Therefore, this research aimed to investigate the implementation of the Photomath application in algebra learning within schools in border areas.

2. METHOD

This study employed a mixed-method research approach, integrating both qualitative and quantitative analyses [26]. After receiving ethics approval, the research was conducted. The sample of this research were 31 eighth-grade students from a border-area school in East Nusa Tenggara, Indonesia. Parental and student consent was obtained before data collection. The sampling technique used was purposive random sampling.

Data were collected through algebraic tests and questionnaires. The qualitative approach was used to analyze the implementation of Photomath in the learning process, interpret students' cognitive learning outcomes, and explore perspectives from both teachers and students regarding motivation, beliefs, and readiness. Meanwhile, the quantitative method was applied to reinforce the findings on cognitive learning outcomes, measured through pre-tests and post-tests. Additionally, it was used to analyze Likert scale questionnaire results assessing teachers' viewpoints, as well as students' motivation, beliefs, and readiness.

The quantitative component followed a pre-experimental one-group pretest-posttest design, the simplest form of research design, where a single group is observed before and after exposure to a treatment or intervention. Data analysis was conducted using descriptive analysis techniques.

O_1	X	O_2

Figure 1. One-group Pretest-posttest Design

Note:
O_1 : Pre-test
X : Learning algebra using Photomath
O_2 : Post-test

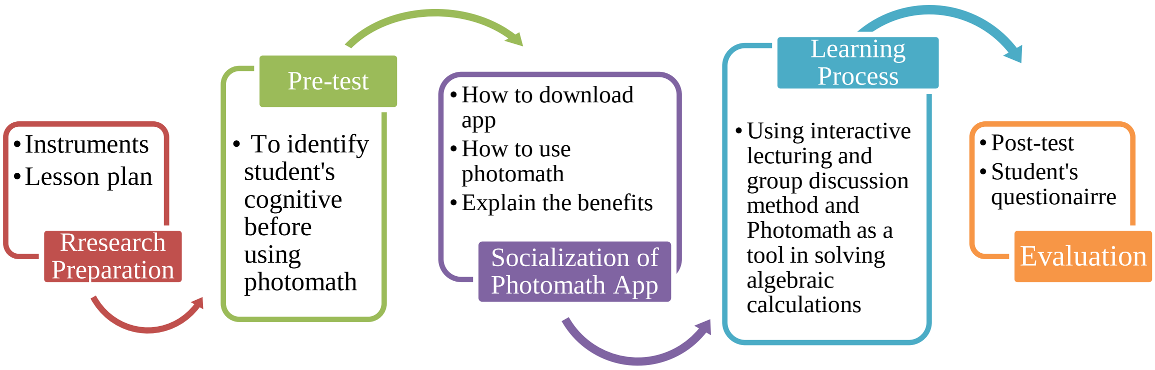

Figure 2. Research Procedure

3. RESULTS AND DISCUSSION

This section describes the implementation of using Photomath in learning process, the impact of using Photomath toward cognitive learning outcomes, the impact of using Photomath toward teacher's view, and the impact of using Photomath toward student's learning motivation, belief, and readiness. These aspects are explored to provide a comprehensive understanding of Photomath's role in the educational context

3.1 The Implementation of Photomath in Learning Process

Algebra learning in grade 8, with the objective that students could perform algebraic calculations, was conducted with the assistance of the Photomath application. The learning process followed several stages: conducting a pre-test, introducing the Photomath application, implementing algebra learning with Photomath, and evaluating the learning outcomes. The direct instruction method was used, with Photomath serving as a supporting tool. This section describes the introduction of the Photomath application and its integration into algebra learning.

The introduction to Photomath took place on the first day of the study. During this session, students received instructions on how to download, use, and benefit from the application. They learned how to install Photomath on their mobile devices via the Play Store for Android or the App Store for iOS. For laptops, students were informed that they would need to download an Android emulator before installing the app. After the introduction, students practiced using Photomath on their respective devices.

One of the challenges encountered was that some students did not have mobile phones or had not brought them to class. Additionally, some students reported limited internet access in their living areas. This issue was anticipated in the planning phase, considering the diverse backgrounds of the students. The teaching team also prepared contingency measures to ensure inclusivity. To address this, students without phones were allowed to share devices with classmates or borrow one from the instructors (researchers). The instructors ensured that all students experienced using Photomath by guiding them through its features, following the step-by-step solutions, and capturing algebraic problems using the application.

Figure 3. Socialization of Photomath

On the second day, the pre-test was administered, followed by the algebra learning process using Photomath. The lesson began with a review of algebraic operations and the presentation of example problems. It is important to note that the students participating in this study had previously learned algebra. This prior knowledge provided a foundation that allowed students to engage more confidently with the learning material. The use of Photomath served to bridge any gaps in understanding by offering instant feedback. After the review, students were given assignments to complete in groups using the Photomath application. They were encouraged to solve problems independently with the aid of technology, promoting self-directed learning and helping them develop the habit of studying independently anytime and anywhere [27]. On the third day, students continued working on their group assignments, followed by the administration of the post-test.

Figure 4. Students Work in Groups

The group assignment consisted of four to five students, with one instructor available to assist when needed, either with using the Photomath application or understanding the material. The first step required students to attempt solving the algebraic problems on their own. Then, they used the Photomath application to capture the problems and compare their solution steps with those provided by the app. This process allowed students to evaluate their problem-solving approaches and understand the step-by-step solutions offered by Photomath.

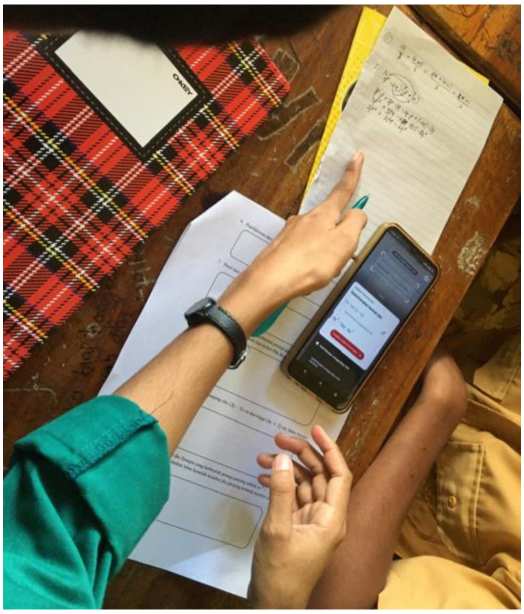

Figure 5. Comparing Student’s Answer and Photomath

Through this comparison process, students deepened their understanding of algebraic operations. In Figure 5, students were observed working on a two-term algebraic multiplication problem. They compared their solutions with the step-by-step process provided by Photomath. This comparison revealed missing steps, calculation errors, and, in some cases, a lack of understanding of how to approach the problem. This process also encouraged students to reflect on their problem-solving habits and become more aware of common pitfalls. The differences between students' pre-test and post-test answers highlighted these gaps. Before using Photomath, many students made calculation errors, skipped essential steps, or had no clear strategy for solving the problem.

During the post-test, students demonstrated improved problem-solving skills by following the correct steps and obtaining accurate results. The instructors allowed students time to analyze and learn from the solution steps provided by Photomath. Students were encouraged to explore and discover solutions independently, seeking guidance from instructors only when necessary. This approach emphasized self-directed learning, reinforcing the habit of using technology as a supportive tool [28]. When students recognized the usefulness of Photomath in their learning process, they became more motivated to solve mathematical tasks independently. They perceived the tool as a valuable aid that helped them complete algebra problems quickly and effectively, fostering greater confidence in their mathematical abilities [29].

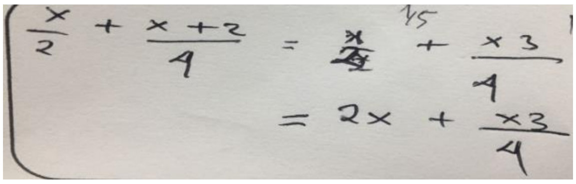

Figure 6. Student's Pre-test Answer

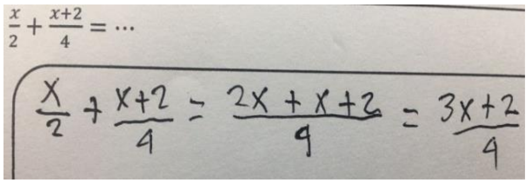

Figure 7. Student's Post-test Answer

This finding reveals that Photomath helps students complete steps they may forget or not fully understand. It also supports students in deepening their understanding of algebra through the clear, step-by-step instructions provided by the application. Additionally, Photomath encourages independent learning and increases students' enthusiasm for solving problems. When students struggle with a problem, Photomath offers guidance, making the learning process more engaging and less frustrating.

These findings align with the research of Pikri et al. [30], who suggests that learning assisted by Photomath enables students to solve problems more effectively by following the available instructions. However, Photomath has limitations in interpreting word problems. The application can only process mathematical equations, meaning students must still rely on their understanding of algebraic concepts to translate real-world problems into equations. Essentially, Photomath serves as a valuable tool for guiding students through the procedural steps of solving mathematical equations but does not replace the need for conceptual understanding [23].

3.2 The Impact of Photomath toward Cognitive Learning Outcomes

This section discusses students' cognitive learning outcomes based on the pre-test and post-test results. Each test had a maximum score of 100. As shown in Table 1, there was an increase in the average score from the pre-test to the post-test, with an overall improvement of 36.26%. This indicates that the use of Photomath in algebra learning contributed to enhancing students' understanding and problem-solving skills.

Table 1. Algebraic test result

Instrument	Number of students	Min. score	Max. score	Mean	Std. deviation
Pre-test	31	0	32	9,87	6,55
Post-test	31	6	94	46,13	24,92

The findings presented in Table 2 show the results of a t-test conducted to determine the significance of learning outcomes before and after using the Photomath application. The hypothesis for this test was H_0 or Null Hypothesis (There is no significant difference between pre-test and post-test scores in algebra learning using Photomath) and H_a or Alternative Hypothesis (There is a significant difference between pre-test and post-test scores in algebra learning using Photomath).

The results indicate a significant difference between the pre-test and post-test scores. Furthermore, the t-test, conducted at a 5% significance level, confirmed this difference. The null hypothesis (H_0) was rejected, as the significance level obtained from the test was 0.000 < 0.05. This finding suggests that the use of Photomath had a statistically significant impact on students' algebra learning outcomes.

Table 2. The Result of the t-test

95% Confidence Interval of the Difference								
Instrument	**N**	**t**	**Std. Deviation**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Lower**	**Upper**
Pre-test	31	7,925	6,55	30	0.00	10,23	7,6048	12,858
Post-test	31	10,345	24,92	30	0.00	46,3567	37,2395	55,4739

3.3 The Impact of Photomath toward Student's Learning Motivation, Belief, and Readiness

Another instrument used to measure students' learning motivation, belief, and readiness was a student questionnaire. The learning motivation indicators reflected students' enthusiasm and eagerness to learn algebra with the help of the Photomath application. The belief questionnaire assessed the extent to which students trusted Photomath as a supportive learning tool, while the readiness questionnaire evaluated how prepared students were to use the application in their learning process.

Table 3. Learning Motivation Frequency

Indicators	**Strongly Disagree**	**Disagree**	**Less Agree**	**Agree**	**Strongly Agree**
Having high motivation when teacher uses Photomath	3,23%	3,23%	6,45%	41,94%	45,16%
Enjoying learning algebra using Photomath	3,23%	6,45%	3,23%	48,39%	38,71%
Paying attention of the algebra topic explained by teacher using Photomath	3,23%	6,45%	3,23%	48,39%	38,71%
Asking the question along algebra class using Photomath	3,23%	3,23%	12,90%	45,16%	35,48%
Showing self-confidence in solving the problem cause help of Photomath	3,23%	9.68%	0%	32,26%	54,84%
Average	3,23%	5,808%	5,162%	43,228%	42,58%

According to Table 3, 14 students strongly agreed that they had high motivation when the teacher used Photomath. Fifteen students agreed that they enjoyed learning algebra with Photomath and paid close attention to the algebra topics explained using the application. This suggests that Photomath successfully captured students' interest and encouraged active engagement with the material. Additionally, 14 students agreed that they actively asked questions during algebra lessons with Photomath, while 17 students strongly agreed that they felt more confident in solving problems due to the support provided by Photomath.

These findings suggest that students who experienced high motivation when using Photomath recognized its usefulness in solving algebraic tasks. This indicates that motivation can play a pivotal role in shaping students' perception of digital learning tools. This positive experience may have contributed to increased self-confidence, which, in turn, could further enhance their motivation to use Photomath as a learning tool [31]. Such tools can support independent learning.

Table 4. Belief Frequency

Indicators	Strongly Disagree	Disagree	Less Agree	Agree	Strongly Agree
Photomath is an interesting application to learn algebra.	3,23%	3,23%	9.68%	19,35%	64,52%
Photomath leads to do independent learning.	0%	3,23%	3,23%	29,03%	64,52%
Photomath guides comprehend and solving algebraic equation.	0%	3,23%	0%	35,48%	61,29%
Photomath supports 21st learning using technology.	3,23%	3,23%	16,13%	41,94%	35,48%
Photomath must be involved in learning at class.	3,23%	0%	3,23%	29,03%	64,52%
Average	1,938%	2,584%	6,454%	30,97%	58,07%

According to Table 4, 20 students strongly agreed that Photomath is an interesting application for learning algebra, promotes independent learning, and should be integrated into classroom instruction. Additionally, 19 students strongly agreed that Photomath helps them understand and solve algebraic equations more easily. Furthermore, 13 students agreed that Photomath supports 21st-century learning by incorporating technology, recognizing its significant impact on education by providing a flexible and efficient learning system. These results indicate that students perceive Photomath as a valuable educational tool that enhances their learning experience, fosters independence, and aligns with modern technological advancements in education [32].

Table 5. Readiness Frequency

Indicators	Strongly Disagree	Disagree	Less Agree	Agree	Strongly Agree
I have known and have read Photomath before.	38,71%	38,71%	22,58%	0%	0%
I usually use Photomath for learning the next topic before the class is started.	51,6%	35,48%	12,90%	0%	0%
I will tell my colleagues about my experience using Photomath.	3,22%	6,45%	6,45%	38,71%	45,16%
I understand how use Photomath in learning algebraic equation.	6,45%	3,23%	19,35%	41,94%	29,03%
I will use Photomath for helping me to do algebraic homework.	0%	3,22%	12,90%	9,68%	74,19%
Average	20%	17,418%	14,84%	18,1%	29,68%

According to Table 5, 12 students either strongly disagreed or disagreed that they had known about Photomath before the study. Additionally, 16 students strongly disagreed that they regularly used Photomath to study upcoming topics before class. This supports the earlier finding that the majority of students were unfamiliar with Photomath prior to the study. However, 14 students strongly agreed that they would share their experience of using Photomath with others. Moreover, 13 students agreed that they understood how to use Photomath for solving algebraic equations, while 23 students strongly agreed that they would use Photomath to help them complete algebraic homework.

Although some students were initially unfamiliar with Photomath, they believed that it could assist them in solving mathematical problems, particularly algebra. Observing the features and functionality of the application, students expressed confidence that Photomath is a tool that can be learned and used independently due to its simplicity. This aligns with the concept of self-efficacy [33]. Finding from Cai *et al.* [34] uggest that students with high self-efficacy are more engaged and involved in learning activities using technology. Additionally, research indicates that self-efficacy and mathematics achievement reinforce each other, influencing student engagement in the classroom [35]. This implies that students' attitudes toward technology are closely related to their self-efficacy. The study by Abidin *et al.* [36], which distributed open-ended questionnaires to 13 to 15-year-old students in Indonesia and analyzed the results using IBM SPSS, revealed that students generally had positive attitudes toward using technology in mathematics classrooms.

3.4 The Impact of using Photomath toward Teacher's View

To see the teachers' responses regarding the Photomath application, one mathematics teacher who taught in the research class was given a questionnaire that measured the teachers' knowledge regarding Photomath and the teachers' confidence in using and teaching students to use Photomath.

Table 6. Teacher's View Frequency

No	Indicators	Score	No	Indicators	Score
1	Mathematics learning in the classroom could be integrated to the technology.	5	6	Photomath forces student to be an independent learner.	5
2	I have known and have heard Photomath before.	4	7	Photomath is an easy-to-use technology.	5
3	I have used Photomath for my business or for learning in my classroom.	3	8	Photomath application provides clear solution stages, making it easier for students to learn algebra.	5
4	Learning algebra using Photomath makes learning more effective.	5	9	Photomath helps students to focus during the learning process.	5
5	Photomath could help student to learn algebra.	5	10	Learning algebra with Photomath could help student in understanding and solving the problem.	5

The mathematics teacher strongly agreed with statements 1, 4, 5, 6, 7, 8, 9, and 10, agreed with the remaining statements, and expressed less agreement regarding the use of Photomath for business or in regular classroom instruction. Overall, the teacher demonstrated sufficient knowledge about Photomath and recognized its benefits in enhancing students' learning experiences. The teacher believed that Photomath helps make mathematics learning more effective and supports independent learning among students. However, the teacher did not consider Photomath as a primary tool for daily teaching or classroom use, indicating that while it is a useful supplement, it may not fully replace traditional instructional methods.

Table 7. Descriptive Analysis of Student's Questionnaire

Variables	N	Scale	Mean	Percentage	Level
Learning motivation	31	1-5	4,15	82,97%	Very strong
Belief	31	1-5	4,40	88,13%	Very strong
Readiness	31	1-5	3,95	78,97%	Strong

Table 7 presents the strength of variables measured in students' perceptions of Photomath. The results indicate that students' learning motivation was very strong toward using the Photomath application. Similarly, students' confidence in Photomath was sturdy, revealing that they believed it to be an engaging tool for learning algebra, promoting independent learning, and deserving of integration into classroom instruction [37]. However, students' readiness was at a strong level, rather than very strong. This was reflected in their initial uncertainty about Photomath before the socialization session. Nonetheless, after being introduced to Photomath, students expressed willingness to share their experiences, gained an understanding of how to use the application for solving algebra problems, and showed intent to use it for completing their homework. This was attributed to Photomath's user-friendly interface and step-by-step answer instructions, which helped students systematically approach problem-solving [30]. Based on the findings, students had very strong motivation and confidence in Photomath and had strong readiness.

Several factors may have influenced these results, particularly students' study habits. Many students may have had an inherent desire to learn but previously gave up when encountering difficulties due to a lack of accessible learning companions or tools [38]. This lack of support hindered their independent learning skills. However, after being introduced to Photomath, students felt motivated to study independently and developed trust in the application's ability to guide them through algebraic problem-solving. The presence of a reliable and interactive tool like Photomath gave students a sense of reassurance when navigating complex mathematical problems.

Moreover, students are responsible for self-regulating their learning habits [39], [40]. Thus, integrating Photomath into classroom activities can help them develop independent learning strategies. Self-regulated learning and modern technology are interrelated [41], meaning that students who experience the benefits of technology tend to regulate their learning more effectively, fostering independent study habits and academic problem-solving skills. As students increasingly engage with digital tools, they become more proactive in managing their learning processes and time.

Beyond these findings, this study aligns with 21st-century learning principles, as the implementation of technology-based learning can enhance critical thinking, problem-solving, communication, collaboration, creativity, innovation, and information literacy. However, a limitation of this study was its small sample size, limited to eighth-grade students. Future research should involve a larger sample size to further examine students' attitudes toward technology in mathematics learning.

4. CONCLUSION

According to the findings and discussion, implementing a learning process integrated with the Photomath application must begin with a socialization phase. This phase introduces students to the application by explaining how to download, use, and benefit from it. Photomath helps students complete steps they may forget or not yet understand, encouraging independent learning. The study revealed a significant difference between students' pre-test and post-test scores in learning algebra using Photomath. Additionally, 43.23% of students agreed that Photomath could establish learning motivation, while 58.07% strongly agreed that it supports both algebra learning and independent study. Regarding readiness, 29.68% of students strongly agreed that they felt prepared to use Photomath. From the teachers' perspective, mathematics teachers demonstrated sufficient knowledge about Photomath and believed in its benefits for enhancing students' learning effectiveness and fostering independent study. Based on the findings, using Photomath in border-area schools provides several advantages, although challenges such as the lack of smartphone access and limited prior knowledge of the application still exist. Future research should ensure that students have sufficient knowledge of technological tools to align with the research objectives. The study implies that integrating Photomath into border-area schools can be beneficial in supporting students' self-study efforts.

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AUTHOR CONTRIBUTION STATEMENT

MMLS contributed to the conceptualization of the manuscript, writing the original draft, methodology, formal analysis, editing, investigation, and visualization. CNS contributed to supervision, validation, formal analysis, writing—review and editing, and visualization. LH contributed to supervision, validation, formal analysis, and visualization. SN contributed to writing—review and editing, and visualization. FD contributed to supervision, validation, and writing—review and editing.

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