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**RESEARCH ARTICLE**

## Photomath on Students' Mathematical Competence: Basis for Delivery Plan Update

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**ABSTRACT**

This study investigates the impact of PhotoMath on the mathematical competence of Senior High School students at a university in Cebu during the Academic Year 2024–2025 to inform updates to the institution's delivery plan. Using a quasi-experimental design, the research compared the posttest performance of control and experimental groups, analyzing data with means, standard deviations, weighted means, and t-tests. The results showed a significant improvement in the experimental group's performance ( $M = 29.42$ ,  $SD = 6.18$ ) compared to the control group ( $M = 25.82$ ,  $SD = 6.09$ ;  $p = 0.017$ ). PhotoMath was also perceived to have a high impact on learning experiences, academic performance, motivation, self-reliance, and AI dependency. The study concludes that PhotoMath effectively enhances mathematical competence and recommends its integration into the delivery plan to improve learning outcomes for General Mathematics.

**KEYWORDS**

AI dependency, mathematical competence, motivation, PhotoMath, quasi-experimental design, self-reliance.

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### INTRODUCTION

The 21st century has posed an ambitious promise in developing the educational landscape. Mathematics pre-service teachers were ideally immersed and molded to keep innovating in their teaching practices. One of the innovations that is heavily observed is the integration of Artificial Intelligence as part of the curriculum. Along with the rapid technological developments, a mathematical application package known as PhotoMath has developed. This mobile application is an AI platform for both iOS and Android that uses Optical Character Recognition (OCR) technology to scan math equations using the mobile camera to provide a worked solution subsequently. The application recognizes equations of both printed and handwritten and provides step-by-step calculations and graphical solutions (The Learning Counsel, 2024).

The latest TIMSS (Trends in International Mathematics and Science Study) report for 2023 reveals several key insights into international math performance among fourth and eighth-grade students. Notable findings from TIMSS 2023, that the top-performing countries in mathematics remain consistent with previous cycles, with East Asian countries like Singapore, Hong Kong, and Korea leading the rankings. Additionally, several countries showed significant improvements in their mathematics scores compared to previous cycles, reflecting successful educational reforms and practices. However, some countries experienced declines, highlighting areas needing attention and potential policy intervention. This result was also the same as the previous TIMSS cycle which was released in 2019 with 36 participating countries.

In the TIMSS 2019 assessment, the Philippines ranked the lowest among 58 participating countries in mathematics for Grade 4 students, scoring an average of 297, which is significantly below the TIMSS Low International Benchmark of 400. Only 19% of the students reached the Low Benchmark, indicating they had some basic mathematical knowledge, while 81% did not meet

this level. This performance highlighted substantial deficiencies in mathematical proficiency among Grade 4 students (Mullis et al., 2020). The TIMSS 2023 results show a continuation of challenges in mathematics for Filipino students, with overall scores remaining below the international average, reflecting ongoing issues in mathematical competencies among students (Mullis et al., 2020). Specific areas of struggle included basic number operations and algebra for grade 8 students, with many students demonstrating difficulty in applying mathematical concepts to real-world problems. Thus, highlighted the need for significant improvements in mathematics education. These significant results at both global and national levels were also personally observed since teaching mathematics is the professional inclination of the researcher. The said observation is specific to Senior High School STEM Grade 11 students at Cebu Doctors' University.

The status of students' mathematical competence at Cebu Doctors' University, based on the previous school year 2023-2024, highlights a concerning trend. The average score for the first quarterly assessment in the General Mathematics course was 22.02 (SD = 7.24), and for the second quarterly assessment, it was 25.04 (SD = 8.01). Both averages are significantly below the DepEd mandated minimum passing rate of 60%. This reveals a gap in students' understanding and application of mathematical concepts, raising concerns about their overall competence in the subject. The researchers also encountered the critical issue of consistently low performance in these assessments, indicating the need for targeted interventions to address the challenges in the learning environment and improve outcomes.

Empirical evidence has shown many solutions to address the gaps or even the loss in learning mathematics, many results prompted the Department of Education (DepEd) to acknowledge these findings and express their commitment to improving the curriculum and teaching methods to enhance student outcomes in future assessments. Moreover, previous studies have shown the effectiveness of Artificial Intelligence (AI) specifically in the integration of the PhotoMath mobile application as a learning tool in the enhancement of the mathematics performance of the students. It is mainly addressing the issue of student's low scores in math courses. None of these empirical studies discusses the comprehensive impact of PhotoMath Intervention on the different dimensions, such as learning experience, academic performance, Motivation, Self-reliance, and AI dependency.

A researcher, as part of the academic community who oath to deliver mathematics competency, particularly in algebraic manipulation and solving equations and inequalities, have consistently faced significant challenges. The struggling student in the classroom setting is typically stressed when they encounter learning activities that involve solving for the unknown variable in Algebra, applying the additive inverse and multiplicative inverse in solving for equations and inequalities are usually forgotten, and worst, these students have dilemmas in applying fraction rules in simplifying the solution. Due to this daily encounter at the university, the researcher intends to navigate an Artificial Intelligence platform known as PhotoMath to address and mitigate this phenomenon among the Senior High School STEM Grade 11 students.

Hence, this study aims to investigate the impact of PhotoMath Intervention on the mathematical competence among Senior High School students at a private institution in Talisay City, Cebu during the academic year 2024-2025 as a basis for updating the delivery plan.

## **Theoretical Background**

The study is grounded on several theoretical frameworks that collectively support its exploration of mathematical competence and the integration of technological tools. Cognitive Load Theory (Sweller, 1988) emphasizes optimizing cognitive resources to enhance learning efficiency, particularly when solving complex mathematical problems. Information Processing Theory (Loc et al., 2019) explains how learners encode, store, and retrieve information, highlighting the role of structured instruction in improving problem-solving skills. Instrumental Theory (Bikner-Ahsbabs et al., 2016) underscores the role of tools, such as Photomath, in shaping and mediating mathematical knowledge. Finally, Situated Learning Theory (Lave and Wenger, 1991) emphasizes learning as a contextual and social process, highlighting the importance of engaging students in authentic problem-solving activities. The study is further anchored on DepEd Order No. 35, s. 2016, which institutionalizes collaborative professional development strategies to enhance teaching and learning, and DepEd Order No. 31, s. 2019, which promotes the standardized and professional use of educational tools and resources. These theories and legal bases provide a robust foundation for the study's objectives.

Cognitive Load Theory (CLT) represents a framework for describing the workload of working memory during complex learning and problem-solving tasks, in particular with respect to topics such as mathematics. Information processing mechanisms according to the cognitive load theory (CLT) is integral to the design of issues in apps like Photomath, as it clarifies how an app can provide a means for learners while minimizing cognitive overhead and burdening their memory (Sweller, 1988). Photomath breaks down problems into bite-sized chunks and deconstructs core concepts to provide straightforward, step-by-step solutions which minimizes extraneous cognitive load as students are less overwhelmed by the volume of content on each page (Zheng & Gardner, 2020).

This is especially important concerning the relationships between cognitive load and students' mathematical ability. The high intrinsic cognitive load associated with the inherent complexity of mathematical tasks can cause learning problems, especially for students who have less prior knowledge (Zheng & Greenberg, 2020). To address this issue, Photomath provides work examples and visual aids that are in line with Cognitively Guided Instruction best practices. The app helps students construct schemas or

mental frameworks so that they can find it easier to assimilate new learning with the knowledge base already in place (Yeo & Tzeng, 2020). This instructional design improves both problem-solving and math proficiency through time.

Additionally, the use of CLT in the area of educational technology like Photomath reveals essential features of instructional design in mathematics pedagogy. Proper practice of CLT initiatives enhance the learning outcomes because the course content are aligned with learning abilities of an individual (Zheng & Gardner, 2020). For example, the use of interactive buttons and tabs within the application of the app to help the students to engage into active learning, is a component of managing cognitive load. When linking the application characteristics with cognitive load theory, educators could extend the usage of the particular technology for the development of the students' mathematics computational skills and their performance in other subjects as well, filling the gap between understanding and application of the math concepts (Sweller et al., 2019).

The information processing theory of learning implies that learners acquire, organize, store, and retrieve information throughout the learning process. Within the educational field specifically applied to mathematics learning, this theory puts weights on previous learned information, on the internal-manipulated information, and on the problem-solving techniques. Cognitive load is a concept defined as amount of work that the learner needs to invest in the understanding of the information. Other elements like instructional approach, content complexity, as well as the learners' background information can manifest and impact cognitive load and learners' outcomes (Loc et al., 2019).

Mobile application known as Photomath that provides solutions to individual mathematics problems can be explained under the information processing theory. On the one hand, by using Photomath and observing the solutions, it is possible to decrease the cognitive load and improve problem-solving; at the same time, overdependence on the application may hinder the development of knowledge and strategies as well as lead to the inability to recall information from memory (Loc et al., 2019).

From the information processing theory, Photomath should complement other teaching methodologies in order to deliver effective teaching. Teachers should assist students in the construction of their self-solutions and urge students to recall the stored information in order to solve mathematical questions.

The instrumental theory emphasizes the use of instruments in learning processes. This theory emphasizes that in the learning of mathematics, the use of tools is crucial and these tools include, calculator, computers and manipulatives. This indicates that the use of these tools can assist learners to reason and solve mathematical problems with ease due to better visualization.

According to the instrumental theory, Photomath can act as a resource that can help students visualize ideas and search for patterns. As pointed out by Bikner-Ahsbabs et al. (2016), technology helps with learning through visualization and guidance as found in the application of Photomath. However, the use of the application should be done alongside other mathematical aids and resources as reliance on the application may not foster the development of a deep understanding of mathematics.

Teachers should assist their students in choosing the correct Mathematical tool to use while learning, including Photomath. The selection of tools should be informed by the learning targets as well as the characteristics of the learners in the class.

SLT emphasizes that learning is most effective when it is situated within the context of real-world practices and activities. According to this theory, learning is not just about acquiring abstract knowledge in isolation but about participating in authentic, social practices within a community of practice. In other words, learners engage in active participation and collaboration with more experienced members of a community, thus learning by doing.

The integration of Photomath in the classroom aligns with Situated Learning Theory because it provides a practical, context-based tool that can be used in collaborative, real-world scenarios. Photomath helps students engage in authentic mathematical problem-solving, which mirrors real-world situations where mathematical skills are needed. Instead of learning abstract formulas in isolation, students use Photomath to solve problems that have direct applicability to the world around them, thereby making the learning experience more relevant and contextual. For example, students could use Photomath to solve problems related to budgeting, construction measurements, or scientific calculations, which can be linked to practical experiences in their everyday lives. This aligns with Situated Learning Theory, which advocates for learning in real-world contexts.

Photomath promotes collaboration by allowing students to work together in pairs or groups to solve problems, fostering interaction and learning within a community. Teachers can also use it in group activities, where students share solutions and strategies, enhancing collective problem-solving.

Generally, Situated Learning Theory emphasizes the role of context, social interaction, and active participation in learning. The integration of Photomath aligns with this theory by helping students engage in real-world problem-solving, collaborate, and progress from beginners to more skilled learners. Photomath fosters a community of practice where students learn through hands-on experience, with the app acting as both a tool and a partner in their learning process.

#### Legal Basis

The importance of continuous professional development for teachers and the integration of innovative teaching strategies and technology in the classroom were present in the DepEd Order No. 35, s. 2016, and DepEd Order No. 21, s. 2019. This also supports the theories and incorporates the impact of using PhotoMath Intervention on Students' mathematical competency.

DepEd Order No. 35, s. 2016, introduces the Learning Action Cell (LAC) as a strategy for the continuing professional development of teachers within the K to 12 Basic Education Program. This order aims to improve teaching and learning outcomes through collaborative learning among educators. By incorporating Photomath into classroom instruction, teachers can engage in LAC initiatives where they collaboratively explore and implement technological interventions to enhance mathematical competence. This collaboration allows teachers to share best practices and collectively analyze the impact of Photomath on student learning, contributing to continuous professional growth and instructional improvement. Furthermore, the research findings on the impact of Photomath can inform data-driven decisions within the LAC framework, guiding teachers in refining their instructional strategies to better meet students' needs.

Another legal basis that can be use in this study is the DepEd Order No. 21, s. 2019, where it provides policy guidelines for the K to 12 Basic Education Program, emphasizing the importance of a holistic, learner-centered approach to education. Integrating Photomath aligns with this policy's emphasis on innovative and effective instructional strategies to enhance learning outcomes. The use of digital tools supports the curriculum by providing diverse and adaptive learning resources. Moreover, the Photomath intervention supports a learner-centered approach by allowing students to engage with content at their own pace and receive immediate feedback, which is critical for mastering complex mathematical concepts. The immediate feedback provided by Photomath can also be used as a formative assessment tool, helping teachers identify areas where students struggle and adjust instruction accordingly.

By aligning the research with these set of DepEd Orders, this thesis supports the ongoing efforts of the Philippine education system to improve teaching and learning through evidence-based practices and professional development. The findings from this study can inform updates to teaching plans and strategies, promoting the integration of technological interventions like Photomath to enhance student outcomes in mathematics.

#### Related Studies

Teaching and learning have evolved over the past hundred years. The use of academic aids, learning tools, and/or Web applications has significantly increased for the advancements of students with the rise of technological improvements (Lydia et al., 2023). In a study conducted by Williams (2020), several factors were identified regarding why students opt for digital applications and websites when tackling mathematical tasks: to verify answers and build confidence in answering, understand the problem-solving process, enhance comprehension of the material, and using these applications provides immediate feedback at any time.

Likewise, a study by Hartono (2019) indicated that students perceived positively the use of the application Photomath in improving their skills in mathematics. The study resulted in a significant improvement in students' academic performance, which was marked by the aggregate increase in mean. This shows that the use of the application may have a positive effect on students' mathematics skills and therefore foster better learning outcomes. This is also supported by Maydawati, Wahyuni, and Astuti (2025) who said that students' interest in learning increased after using the application Photomath as compared to before the use. However, the improvement soared on average calculation of the two sets of data. The study found that the application made the Grade VIII students at SMP Negeri 8 Tapung keener on learning.

Photomath, among many applications for learning and solving mathematics, has gained popularity all over the world. PhotoMath is a mobile application that offers math tutorials with numerous examples and allows learners to solve both printed and handwritten problems, showcasing how mobile devices' camera functionality can be utilized effectively (Todoranova & Penchev, 2019).

Based on several studies on students' usage of Photomath, Employing the PhotoMath application as a medium for solving mathematical problems can aid students in resolving mathematical problems in different areas such as in advanced calculus courses (Dewi et al., 2023). The integration of Photomath into mathematic teaching and learning also has a significant increase in algebra test scores of students (Saundarajan et al., 2020), an increase in the student's achievement and interest in algebra (Zain et al., 2023), and increase in students' engagement with Photomath as an intervention indicating its effectiveness in teaching elementary algebra (Igcasama et al., 2020).

Furthermore, Putri, S. Y. J., & Cahyanti, C. (2024) utilized a systematic literature review approach based on the PRISMA framework disclosed several research methods utilized in Photomath-related studies, publication patterns over the last few years, and proof of its impact on students' problem-solving abilities. Teachers were suggested to incorporate the Photomath application as an additional learning tool for mathematics to enable students to effectively comprehend and solve sophisticated mathematical problems.

Findings from the study by Nurhayati et al. (2020) show that the teaching and learning process assisted by Photomath on System of Linear Equation in Two Variables (SLETV) materials led to an improvement in students' conceptual understanding. This improvement was evidenced by the number of questions students could answer after the teaching and learning process. Consequently, the post-test scores were higher compared to the students' pre-test average. Nuhayati et al. pointed out also that majority of the students have already operate Photomath application and this application is also able to support students in learning mathematics so that the students will easily understand and be more self-reliant to learn mathematics.

Avanda, A.Y. & Putri, S.A.W. (2020) showed that mostly of the students were aware of the Photomath application and stated that Photomath did not interfere with their mathematics learning process, and on average, they considered this application

to be just ordinary. While Photomath helps a majority of students, it also has negative impacts such as fostering laziness in thinking and leading students to rely solely on Photomath for solving mathematical problems without manual calculations.

In contrast, some studies suggest that the effect on students' performance would remain the same regardless of the use of Photomath. Igcasama et al. (2020) provided evidence of a higher response in post-test scores compared to pre-test scores, indicating improvement even without Photomath intervention. The authors noted that the small sample size likely influenced these results. However, Igcasama et al. (2020) concluded that Photomath as an intervention had a significant effect on students' performance, particularly in teaching elementary algebra. Their findings suggested that using Photomath as a teaching tool positively impacted educational practices, prompting teachers and administrators to consider integrating such technology into classrooms. Thus, students and teachers could fully utilize Photomath to enhance learning outcomes in the subject.

Many studies have highlighted the potential benefits of utilizing PhotoMath in the classroom. However, there is ongoing debate regarding the allowance of smartphones in educational settings, as they may cause distractions for students. Nevertheless, the consistency in the results of several studies shows a great effect to the learners. Such as the study 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. 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' problemsolving abilities and reduce math anxiety.

In addition, a preliminary investigation on the application of photomath for lower secondary education showed a significant increase in the score of students on the post-test which is after the use of Photomath application, Kumar, J.A. (2020). This finding indicates that the Photomath application was effective for learning the algebraic equations among form two students. Moreover, study showed that there was a significant difference in students' achievement between pre-test and post-test, which means Photomath utilization in the classroom improved the mathematics performance of the learners.

According to Kumar (2020), that students' belief towards Photomath application in solving algebraic equations in mathematics was still at a moderate level. It might be due to Photomath application which was still new to them and only launched recently. This assumption goes along with the students' readiness towards Photomath application in solving algebraic equations in mathematics which were also still at the moderate level. The possible reason might be due to the unreadiness and resistance of the students to change their conventional methods of study to apply the Photomath application. Nevertheless, the students agreed that Photomath application works as an interesting method for them to learn algebraic equations.

Capinding (2023) reported a significant improvement in students' self-reliance following the intervention, with mean scores for each item increasing to a highly positive range ( $M = 3.41-3.73$ ). The standard deviation, which was higher before the intervention ( $SD = 0.54-0.80$ ), decreased after the intervention ( $SD = 0.45-0.50$ ), indicating a more consistent and uniform enhancement in self-reliance. These findings highlight not only the overall improvement in self-reliance but also a convergence in students' responses after using Photomath.

According to Capinding (2020), before the intervention, students demonstrated a consensus regarding their interest in learning mathematics, with mean values ranging from 2.65 to 2.88. This indicates a generally positive attitude toward mathematics learning prior to the intervention. After the intervention, students' interest in precalculus significantly increased, as shown by the rise in mean values to between 3.43 and 3.73, reflecting a heightened interest in the subject. Additionally, the standard deviation of students' responses decreased after the use of Photomath ( $SD$  before = 0.58–0.80;  $SD$  after = 0.45–0.50), suggesting a greater alignment in students' perceptions following the intervention.

Capinding (2020) provided an analysis of student performance before and after the implementation of the Photomath intervention. The findings indicated a significant improvement, as the pretest mean score ( $M = 18.27$ ) was lower than the posttest mean score ( $M = 29.12$ ). Additionally, the standard deviation decreased after the intervention ( $SD$  before = 5.53;  $SD$  after = 1.49), suggesting that student scores became more closely clustered around the mean, reflecting improved consistency in performance outcomes.

The t-test results highlight an increase in self-reliance and interest among students following the intervention, indicating greater self-sufficiency and a heightened enthusiasm for tackling pre-calculus problems. Additionally, the intervention is associated with a significant improvement in students' performance, suggesting its positive impact (Capinding, 2023).

Sinha (2023) notes that calculators become more engaging when they can solve problems in a broader context, such as with the use of artificial intelligence (AI) calculators. AI has emerged as a significant and transformative tool across various fields, including education. Recently, there has been growing interest in the application of AI in mathematics education due to its potential benefits, such as enabling personalized learning experiences, increasing student engagement, and fostering enhanced problem-solving skills.

Amparo et al. (2022) used PhotoMath as an educational tool in mathematics during online distance learning and found significant evidence of improved student performance in mathematical abilities. Additionally, Saundarajan et al. (2020) demonstrated that PhotoMath promotes learner autonomy and is perceived by students as an engaging method for understanding algebraic equations.

However, not all studies highlight the positive effects of PhotoMath on mathematics instruction. Igcasama et al. (2020) conducted a quasi-experimental study examining the impact of PhotoMath on Grade 7 students' performance in elementary algebra, finding no significant difference between students who used PhotoMath and those who did not. Furthermore, Latham (2020) argued that students who depend on PhotoMath and similar online calculators to complete homework may struggle to understand key concepts, ultimately leading to a weaker foundation for future learning.

According to Riski et al. (2021), a substantial majority of students (80%) agree that using PhotoMath can enhance self-reliance in mathematics education. This impact is notably evident when applied to SLETV (Science, Language, English, Technology, and Vocational) materials. Increased interest driven by such tools is particularly encouraging, as greater enthusiasm often leads to improved motivation, active participation, and, ultimately, better academic performance (National Academies of Sciences, Engineering, and Medicine [NASEM]).

Hulagpos et al. (2025) observed a notable improvement in students' independence in learning algebra after the intervention, indicating that implementing the Photomath application enhanced Grade 7 students' capacity to engage with algebraic concepts independently. Similarly, Angeles, J. G. B., & Lapinid, M. R. C. (2024) that in a flipped classroom, significant improvement on students' achievement motivation and interaction becomes evident. These findings are consistent with a wide body of research highlighting the significant role of extrinsic motivation in the learning process. Likewise, Zain et al. (2023) demonstrated similar outcomes, showing that the use of Photomath as an intervention improves both student performance and their interest in learning mathematics.

In general, the current literature emphasizes the potential of technology, especially tools like PhotoMath, in improving students' mathematical abilities. Prior research reveals that such applications not only support comprehension but also promote increased engagement and perseverance in mathematics learning. This study, by exploring the impact of PhotoMath on Senior High School students at a university in Cebu, seeks to add to the expanding body of evidence, offering valuable insights that will guide the revision of delivery plans, ensuring that instructional methods are tailored to meet the changing needs and preferences of contemporary learners.

## **OBJECTIVES OF THE STUDY**

This study aimed to investigate the impact of PhotoMath on the mathematical competence of Senior High School students at a university in Cebu during the Academic Year 2024-2025 as a basis for a delivery plan update.

Specifically, it sought to answer the following sub-problems:

1. What is the posttest performance of the Senior High School students in General Mathematics in the control group and experimental group?
2. Is there a significant difference between the posttest performance of the control and experimental groups?
3. What is the impact of PhotoMath on Senior High School Students after the intervention in terms of the following domains: learning experience; academic performance; motivation; self-reliance; and AI dependency?
4. Based on the findings, what updates to the delivery plan may be made?

### Statement of the Null Hypothesis

Based on the objectives of the study, the following null hypothesis was tested at a 0.05 level of significance:

Ho1: There is no significant difference between the posttest performance of the control and experimental groups.

## **METHODOLOGY**

### Research Design

The study used the quantitative quasi-experimental non-equivalent group posttest design as its research design to determine the impact of PhotoMath on the mathematical competence of senior high school students at the University as a basis for updating the university's delivery plan. This research approach is structured to ensure relevant results are gained when examining the relationship between the effectiveness of PhotoMath and the mathematical competency of senior high school students at the University.

Reichardt (2019) explains that quasi-experimental design aims to estimate the effect of a treatment or an intervention assigned to a selected group, or in a non-random process. It resembles an experimental design but is only used when randomized studies are not feasible (Maciejewski, 2018) and when randomized experiments cannot be implemented for ethical reasons (Reichardt, 2019). A quasi-experimental design is an appropriate approach for this research such that the researchers select the control and experimental group and observe how using PhotoMath influences the student's competency.

It is important to carefully select Grade 11 - Senior high school students at the University to ensure that both the control and experimental groups have the same representative of the population; that is why the Grade 11 - STEM Strand was selected in this research. Only two sections with the same Strand were selected in this study in order to eliminate any potential biases. In this

study, the experimental group utilized PhotoMath while the control group did not. The presence of a control group aids in managing external variables and facilitates comparison with the experimental group.

After the collection of data from conducting a test for the control group and experimental group, the data gathered was statistically analyzed by getting the mean of each group and comparing the results of the two groups. The outcome of the data analysis served as a crucial basis for researchers to update the delivery plan.

When assessing the impact of Photomath on the mathematical skills of senior high school students using a quasi-experimental research design, research design can be developed based on the Input-Process-Output (IPO) model. The Input phase aims to gain basic information on the performance of the students in mathematics, their awareness level of Photomath, and other variables that could affect the study findings including the mathematical skills of both the control group composed of non-users and the experimental group composed of Photomath users.

The Process phase consists of four key stages: Data Collection to assess and quantify the use of the Photomath application, Impact Analysis and statistical testing on whether the application influences the competency levels of students, Competency Comparison to compare the efficiency of the Photomath application, and Recommendation Generation to improve Educational Strategies, with input from educators and researchers.

The Output phase is defined as the Updated Delivery Plan based on the results of the study for improving the use of technology such as Photomath in the teaching of mathematics aligned to students' performance data. This type of research design will allow for an informed and closer look at the effects of Photomath among the SHS learners and what recommendations should be made regarding its use in teaching practices.

#### Environment

The study was conducted in a private university in Cebu City, Philippines. This state-run school is under the supervision of the Department of Education. Department of Education granted the University the authority to operate Senior High School effective in the Academic Year 2016-2017.

The study involved the Senior High School STEM Grade 11 students of the university located Mandaue City, Cebu, Philippines. Senior High School STEM Grade 11 students were chosen by the researchers because the selected Grade 11 STEM students represent a diverse range of abilities, backgrounds, and learning styles to obtain a comprehensive understanding of the effectiveness of PhotoMath across various student profiles.

#### Respondents

The research took place in a private higher educational institution situated in North Reclamation Area, Mandaue City, Cebu. In recruiting participants, sampling was employed, participants considering them to be the target sample for the PhotoMath intervention, which was the main focus of the study about improving mathematical competence among Senior High School students. Owing to the quasi-experimental non-equivalent group posttest design employed in the study, an assignment of participants to groups was according to intact class section rather than random selection. Out of a total of 69 students, 36 were assigned to the Experimental Group with identification label from A1 to A36 while 33 students formed the Control Group with identification label from B1 to B33. The Experimental Group was exposed to PhotoMath as an intervention in the mathematical problem-solving process, while control groups used only conventional methods. In the end, both experimental and control groups were given a standardized posttest measuring the students' mathematical competence after a stipulated period. Finally, a posttest score comparison was made with a view to assessing the difference in mathematical competence for the Two groups studied, namely the ones who used PhotoMath and those who did not.

Table 1  
Distribution of the Respondents

Group	ID	Number of respondents	Intervention
Experimental	A1 – A2	36	w/ PhotoMath
Control	B1 – B2	33	w/o PhotoMath

#### Instrument

The study used two instruments to gather data. One is a researcher-made questionnaire while the other one is an adapted questionnaire from Capinding (2024).

General Mathematics Learning Activities in Grade 11. This is a researcher-made standardized questionnaire that is made up of General Mathematics topics, namely: (1) Solving rational equations and inequalities, (2) solves problems involving inverse functions, (3) Solving exponential equations and inequalities, and (4) Solving logarithmic equations and inequalities. (see Appendix C). The questionnaire underwent a reliability test to ensure its consistency and accuracy in measuring the intended constructs. The computed Cronbach's alpha for the instrument is 0.99, indicating excellent internal consistency. This high reliability score suggests that the items in the questionnaire are highly cohesive and effectively measure students' competence in the identified topics.

Assessing the impact of Artificial Intelligence (PhotoMath) on students. This is an adapted questionnaire from Capinding (2024) which consists of a 48-item instrument, categorized into learning experiences, academic performance, career guidance, motivation, self-reliance, social interactions, and AI dependency. This tool is used to assess the impact of Artificial Intelligence on higher education. The researchers excluded career guidance and social interactions because the study is limited only to their view of math as a course after PhotoMath intervention in a classroom setting. The development and validation of this assessment tool were administered to 635 students at the Nueva Ecija University of Science and Technology – Gabaldon campus. The reliability coefficient for each construct is: academic performance ( $\alpha = .92$ ), career guidance ( $\alpha = .91$ ), and self-reliance ( $\alpha = .93$ ) have good reliability coefficients, whereas learning experience ( $\alpha = .88$ ), motivation ( $\alpha = .89$ ), social interaction ( $\alpha = .87$ ), and AI dependency ( $\alpha = .86$ ) have excellent reliability coefficients. The reliability coefficient indicates the reliability of the items in measuring the construct. Furthermore, the moderate reliability coefficient suggests a lack of redundancy among the items.

#### Gathering Procedure

The data-gathering procedure is divided into different stages: processing of transmittal letter, content validation by the math expert from other institution, and administration of the AI assessment tool.

The study started by seeking approval to conduct the study at the University through a transmittal letter addressed to the principal. The principals were informed of the nature of the study. After the approval of the conduct of the study, the researcher-made standardized questionnaire underwent content validity. The researcher-made standardized questionnaire was validated by a math expert from another institution. The 280 Grade 11 students will come from 9 sections, the researcher choose from these 9 sections a control and an experimental group. The handing out of the research questionnaires was done physically. Letters of consent to participate in the study were also be given to the respondents which included the researcher's contact information in case of queries and concerns (see Appendix B). The data gathered were analyzed and interpreted.

#### Statistical Treatment

The following statistics were employed in the study:

Means were used to determine the student's pretest and posttest performance on average for both the control and experimental groups. Standard deviations were used to determine how spread are the scores of the students and the level of impact around the mean. Weighted means were computed to describe the impact of PhotoMath intervention in terms of the identified dimensions, namely: learning experiences, academic performance, career guidance, motivation, self-reliance, social interactions, and AI dependency. The independent samples t-test were used to test the significance of the difference between posttest performance of the control and experimental groups.

#### Ethical Considerations

It was made clear to the respondents that their participation in this study is voluntary, and they are not compelled to participate should they believe it is detrimental to their interest. Furthermore, the participants were informed that the research is conducted solely for academic purposes and the data gathered from them will be exclusively used for such purpose.

**Data Privacy.** The researcher ensured the confidentiality of the data gathered relative to the respondents' personal information and would not be disclosed to the public at any cause. These were guaranteed by performing the activities such as, the names of the respondents are replaced by codes, the sheet containing the name of the respondents is removed and kept or destroyed when no longer needed for the research, the researcher would have the sole access to the code's master list, and files containing research data were password protected and encrypted to keep the data safe.

## **RESULTS AND DISCUSSION**

### **Posttest Performance of the Control and Experimental Groups**

This section presents and analyzes the posttest performance of both the control group and the experimental group. It aims to compare the results to determine the effectiveness of the intervention applied to the experimental group. The analysis provides insights into the differences in performance between the two groups, highlighting any significant improvements or variations that occurred after the implementation of the study's treatment or methodology.

#### Posttest Performance of the Control Group

This section presents the posttest performance of the control group after being exposed to the traditional teaching method. The data highlights their achievement levels and provides a basis for comparing their outcomes with the experimental group. Statistical analysis is used to determine the effectiveness of the instructional method employed.

Table 2 presents the posttest performance of the control group, summarizing the scores obtained by participants after the intervention or experimental period. The data reflects their performance levels and provides insight into their understanding of the subject matter without exposure to the specific intervention applied to the experimental group.

Table 2  
Posttest Performance of the Control Group

Posttest Performance	f	%
Outstanding (41-50)	0	0.00
Very Satisfactory (31-40)	7	21.21
Satisfactory (21-30)	22	66.67
Fair (11-20)	4	12.12
Does Not Meet Expectations (0-10)	0	0.00
<b>Total</b>	<b>33</b>	<b>100.00</b>

*Mean = 25.82 Satisfactory*

*SD = 6.09*

Table 2 illustrates the posttest performance of the control group, categorized into five performance levels: Outstanding (41–50), Very Satisfactory (31–40), Satisfactory (21–30), Fair (11–20), and Does Not Meet Expectations (0–10). The majority of the participants (66.67%) achieved a Satisfactory performance level, indicating a moderate understanding of the subject matter. A smaller percentage (21.21%) attained a Very Satisfactory level, while 12.12% of the group fell under the Fair category. Notably, no participants scored in the Outstanding or Does Not Meet Expectations ranges.

The mean score of the control group was 25.82, corresponding to a Satisfactory performance level, with a standard deviation of 6.09. This suggests that the performance of the participants was moderately consistent, with scores clustering around the mean. These results reflect the typical performance of students without exposure to the intervention applied to the experimental group, providing a baseline for comparison in the study.

The research findings where the majority in the control group achieved a satisfactory performance level might work against the prediction of CLT that high intrinsic cognitive load about mathematics leads to learning problems by students who may have less prior knowledge (Sweller et al., 2019). If CLT were strictly applicable, one might expect a greater percentage of the control group students to fall in the Fair or even Does Not Meet Expectations categories. But moderate performance on the part of the control group indicates that the intrinsic complexity of the subject matter was there but not a barrier for the majority of students to learn. In addition, The lack of tools like Photomath, which may help retrieve and organize information, could explain why no students scored at the highest performance level (Loc et al., 2019).

Moreover, this explains the lack of students achieving Outstanding levels as there are no realistic problem-solving tools such as Photomath, against which the SLT champions contextual tools to augment learning (Nurhayati et al., 2020).

DepEd Order No. 21, s. 2019, emphasizes the significance of innovative teaching methods, indicating that the results for the control group could enhance with the use of tools such as Photomath. This is also supported by the research conducted by Igcasama et al. (2020) and Kumar (2020) indicates that student performance can greatly enhance with the use of interventions such as Photomath, implying that the control group's average performance corresponds with the lack of these resources.

#### Posttest Performance of the Experimental Group

This section presents and analyzes the posttest performance of the experimental group after undergoing the intervention or treatment. The data gathered from the posttest is used to determine the effectiveness of the implemented strategy or program in enhancing the participants' knowledge, skills, or competencies. The findings are discussed in relation to the objectives of the study, providing insights into the impact of the intervention on the experimental group.

Table 3 displays the posttest performance levels of the experimental group, categorized by different performance levels. It includes the frequency of students in each level and their corresponding relative frequencies. This distribution provides an overview of how the participants performed after the intervention, offering a basis for analyzing the effectiveness of the applied methodology.

Table 3  
Posttest Performance of the Experimental Group

Posttest Performance	f	%
Outstanding (41-50)	0	0.00
Very Satisfactory (31-40)	14	38.89
Satisfactory (21-30)	19	52.78
Fair (11-20)	3	8.33
Does Not Meet Expectations (0-10)	0	0.00
<b>Total</b>	<b>36</b>	<b>100.00</b>

*Mean = 29.42 Satisfactory*

$$SD = 6.18$$

Table 3 illustrates the posttest performance of the experimental group, categorized by performance levels, along with their corresponding frequencies and relative frequencies. The data shows that the majority of the participants (52.78%) achieved a Satisfactory performance level, scoring between 21 to 30 points. Additionally, 38.89% of the students attained a Very Satisfactory performance level (31–40 points), indicating a notable portion of the group demonstrated above-average results.

A smaller percentage (8.33%) of the participants performed at the Fair level (11–20 points), while none fell into the Outstanding (41–50 points) or Does Not Meet Expectations (0–10 points) categories. This absence of students in the lowest performance category suggests that all participants demonstrated at least a basic understanding of the tested concepts. The mean score of the experimental group was 29.42, which falls within the Satisfactory category, with a standard deviation of 6.18, indicating moderate variability in the scores. These results suggest that the intervention applied to the experimental group contributed to their overall satisfactory performance, with a significant portion showing above-average achievement.

The results in the post-test that show satisfactory and very satisfactory performance levels lend support to the concept of CLT, where the reduction of cognitive load will improve learning. The ability of Photomath to break down problems into more manageable steps would reduce extraneous load, according to Zheng and Gardner (2020) and Yeo and Tzeng (2020). This might explain the better performance that was seen in the experimental group. Furthermore, Moderate variability in the scores of the experimental group (standard deviation 6.18) could mean effective information processing as students had better organization and retrieval of mathematical concepts due to the PhotoMath intervention. According to Loc et al. (2019), tools like Photomath may help enhance problem-solving and recall when combined with traditional methods.

Such findings from the investigation, however, are consistent with the DepEd Orders supporting the application of technology in teaching. These improvements in performance also underscore the learner-centered approach given in DepEd Order No. 21, S. 2019. This is also supported by by Igcasama et al. (2020) and Nurhayati et al. (2020), its evident significant improvement in the students' performance score as well as conceptual understanding, coining to the research findings of average satisfactory performance on the post-test.

**Significance of the Difference Between the Posttest Performance of the Control and Experimental Groups**

This section examines the significance of the difference between the posttest performance of the control and experimental groups. Through statistical analysis, the results are compared to determine whether the intervention implemented in the experimental group had a significant effect on their performance. The findings provide a basis for evaluating the effectiveness of the applied methodology and its impact relative to the traditional or alternative approaches used in the control group.

Table 4 presents the results of the test of significance conducted to determine whether there is a statistically significant difference between the posttest performance of the control and experimental groups. The table includes key statistical values, such as the mean scores, standard deviations, test statistic, and p-value. These findings are critical in assessing the effectiveness of the intervention implemented in the experimental group compared to the control group.

Table 4  
Test of the Significance of the Difference Between the Posttest Performance of the Control and Experimental Groups

Group	n	Mean	SD	t Stat (critical)	p-value	Significance
Control	33	25.82	6.09	- 2.432 (1.996)	0.017*	Significant
Experimental	36	29.42	6.18			

$\alpha = 0.05$ ,  $df = 67$ , \*significant at 0.05 (two-tail)

Table 4 summarizes the test of significance performed to compare the posttest performance of the control and experimental groups. The results indicate that the mean score of the experimental group (29.42, SD = 6.18) was greater than that of the control group (25.82, SD = 6.09).

A t-test was conducted to determine whether this difference was statistically significant. The computed t-value of -2.432 exceeded the critical t-value of 1.996 at a 0.05 level of significance with 67 degrees of freedom. The corresponding p-value of 0.017 is less than 0.05, confirming that the difference between the two groups' posttest performance is statistically significant.

These findings suggest that the intervention implemented for the experimental group had a significant positive impact on their performance compared to the control group. This indicates the effectiveness of the treatment in enhancing the learning outcomes of the participants.

According to SLT, learning becomes stronger when it is associated with real-world applications. PhotoMath offers real-world problem-solving experience most in line with the tenets of SLT in terms of practice and collaborative learning (Lave & Wenger, 1991). The findings of the study are also supportive of the app's contribution to the increased level of engagement among students and the application of mathematical concepts (Todoranova & Penchev, 2019). The findings support the principles of Cognitive Load Theory (CLT), highlighting the need to reduce cognitive load to improve learning results (Sweller et al., 2019). PhotoMath's detailed, step-by-step explanations help to lessen unnecessary cognitive load, enabling students to concentrate on developing their understanding of mathematical concepts (Zheng & Gardner, 2020; Yeo & Tzeng, 2020). This aligns with the noted enhancements in problem-solving skills and math proficiency among the experimental group.

The test results testify to the Instrumental Theory very clearly. The disparity in mean scores clearly indicates that it is effective in using a tool-and that tool is probably PhotoMath-to help students learn better. The intervention has probably permitted students to reason and facilitate solutions to mathematical problems more easily because it has supposedly provided an effective instrument for solving mathematical problems, according to the predictions of the Instrumental Theory.

According to the present study, use of PhotoMath results in improved posttest score similar to the findings of Capinding (2023) and Igcasama et al. (2020), where the experimental group scored much higher than the control group. Similar interventions of Kumar (2020) and Saundarajan et al. (2020) have explored increased test scores and very good mathematical competency, which has supported the observed good obtainable result to what this research acquired. Moreover, these findings support DepEd order in as far as the use of new innovative approaches and tools such as PhotoMath in education practice is concerned. Such integration has showed great effects on learning outcomes as a product of intervention. Teachers use such technology as PhotoMath to improve students' understanding and problem-solving in Math, resulting in enhanced performance overall school performance.

### Impact of PhotoMath on Senior High School Students

This section explores the impact of PhotoMath on senior high school students across various domains, including their learning experience, academic performance, motivation, self-reliance, and dependency on artificial intelligence (AI). The discussion highlights how the app influences students' engagement and comprehension of mathematical concepts, its role in enhancing or hindering academic achievement, and its effects on intrinsic motivation to learn. Furthermore, the section examines whether the use of PhotoMath fosters self-reliance in problem-solving or promotes a dependency on AI for academic tasks. The findings aim to provide a comprehensive understanding of how PhotoMath shapes students' educational journey and the broader implications for integrating AI tools in mathematics education.

#### Learning Experience

This section explores how PhotoMath affects the learning experience of senior high school students. Learning experience encompasses the interactions, activities, and engagements students encounter while using the Photomath application to solve mathematical problems. The discussion focuses on how Photomath influences students' methods of understanding mathematical concepts, encourages active involvement in problem-solving, and impacts their overall engagement in the learning process. By examining these aspects, the section seeks to provide a deeper understanding of PhotoM effectiveness in improving students' comprehension and its broader implications for their academic development.

Table 5 presents the evaluation of the impact of PhotoMath on the learning experience of senior high school students. The table includes the weighted mean, median, standard deviation, and corresponding level of impact for each statement. These findings provide a detailed perspective on how PhotoMath contributes to enhancing students' learning experiences.

Table 5  
Impact of PhotoMath (Learning Experience)

Statements	Weighted Mean	Median	SD	Level of Impact
Learning Experience				
1. AI has provided interactive and engaging learning materials.	2.92	3.00	0.73	High
2. AI has encouraged critical thinking and problem-solving skills development.	2.64	3.00	0.87	High

3. AI has facilitated hands-on and practical learning experiences.	2.53	2.50	0.88	High
4. AI has enhanced my learning experience by providing personalized content and resources.	2.83	3.00	0.91	High
5. AI has provided real-world examples and case studies to enhance my learning.	2.67	3.00	0.83	High
6. AI has adapted to my learning style and pace, making learning more enjoyable and effective.	2.67	3.00	0.83	High
<b>Overall Rating</b>	<b>2.71</b>	<b>3.00</b>	<b>0.84</b>	<b>High</b>

*Legend: 3.26-4.00 Very High, 2.51-3.25 High, 1.76 – 2.50 Low, 1.00-1.75 Very Low*

Table 5 highlights the impact of Photomath on the learning experience of senior high school students. The results reveal that the overall rating for the learning experience domain is 2.71 (SD = 0.84), which falls under the High level of impact. This indicates that students perceive Photomath as significantly contributing to their learning experience in various aspects.

Among the statements, the highest-rated item is "AI has provided interactive and engaging learning materials," with a weighted mean of 2.92 (SD = 0.73). This suggests that students highly value Photomath's ability to deliver content in an engaging and interactive manner. Similarly, the statement "AI has enhanced my learning experience by providing personalized content and resources" received a high mean score of 2.83 (SD = 0.91), emphasizing the importance of personalized learning materials in improving comprehension.

Other aspects, such as "AI has encouraged critical thinking and problem-solving skills development" (2.64) and "AI has provided real-world examples and case studies to enhance my learning" (2.67), also received high ratings. These findings imply that Photomath is recognized for promoting higher-order thinking and practical application of mathematical concepts. However, the lowest-rated statement is "AI has facilitated hands-on and practical learning experiences" (2.53, SD = 0.88), though it still falls under the High level, indicating room for improvement in engaging students in hands-on tasks.

Overall, the data suggest that Photomath significantly enhances the learning experience of senior high school students by providing interactive, personalized, and engaging materials that cater to their learning styles and pace. These results affirm the value of integrating AI tools like Photomath into educational practices to improve student engagement and comprehension.

The observation that Photomath offers "interactive and engaging learning materials" aligns well with Cognitive Load Theory (Sweller et al., 2019). By delivering information in a dynamic and captivating way, Photomath likely minimizes unnecessary cognitive load. Interactive features can draw students' attention (Zheng & Gardner, 2020), making the learning experience more enjoyable and less taxing on the mind. Engaging resources can help students concentrate on essential concepts and steer clear of distractions (Sweller et al., 2019), thereby enhancing learning efficiency. There is a strong support for Information Processing Theory, findings have shown that with this intervention, learners were able to encode information in a more organized and retrievable manner. The improvement shown by the performance of the experimental group indicates that such an intervention rightly improved their efficiency and effectiveness in processing information.

In addition, these results significantly corroborate earlier works that have proved the impact of apps like Photomath on students' performance and engagement (Saundarajan et al., 2020; Zain et al., 2023; Amparo et al., 2022). Researchers investigating the Photomath app now support a large body of evidence demonstrating that it can significantly enhance students' performance and interest in mathematics, which perfectly aligns with the mean difference observed between the experimental and control groups in the present study.

### Academic Performance

This section examines how Photomath impacts the academic performance of senior high school students. It analyzes the application's influence on students' ability to solve mathematical problems, enhance their test results, and deepen their understanding of mathematical concepts. The discussion highlights the benefits of using Photomath to achieve academic success while also addressing its potential drawbacks. By evaluating its role in academic performance, this section provides valuable insights into the effectiveness of Photomath as a learning tool for improving mathematics achievement.

Table 6 presents the evaluation of the impact of Photomath on the academic performance of senior high school students. It outlines various aspects of academic achievement, including improvements in mathematical problem-solving skills, test scores, and understanding of mathematical concepts. The table includes the weighted mean, median, standard deviation, and the

corresponding level of impact for each statement. These results provide an in-depth understanding of how Photomath contributes to enhancing students' academic performance in mathematics.

Table 6  
Impact of PhotoMath (Academic Performance)

Statements	Weighted Mean	Median	SD	Level of Impact
Academic Performance				
1. AI-based feedback has helped me improve the quality of my assignments and exams.	2.89	3.00	0.78	High
2. AI has provided timely and accurate assessments of my progress.	2.78	3.00	0.80	High
3. AI has assisted me in achieving my learning goals.	2.81	3.00	0.82	High
4. AI-powered tools have helped me identify and address my weaknesses in specific subjects.	2.86	3.00	0.80	High
5. AI has contributed to improving my academic performance.	3.00	3.00	0.86	High
6. AI has helped me prepare for exams more effectively.	2.72	3.00	0.91	High
<b>Overall Rating</b>	<b>2.89</b>	<b>3.00</b>	<b>0.83</b>	<b>High</b>

Legend: 3.26-4.00 Very High, 2.51-3.25 High, 1.76 – 2.50 Low, 1.00-1.75 Very Low

Table 6 highlights the perceived impact of PhotoMath on the academic performance of senior high school students, with an overall rating of 2.89 (SD = 0.83), indicating a High level of impact. This suggests that students find PhotoMath to be a valuable tool in enhancing their mathematics performance.

The highest-rated statement, "AI has contributed to improving my academic performance," received a weighted mean of 3.00 (SD = 0.86), reflecting students' acknowledgment of PhotoMath's role in boosting their overall academic success. Similarly, the statement "AI-powered tools have helped me identify and address my weaknesses in specific subjects" was rated highly at 2.86 (SD = 0.80), emphasizing the application's ability to target and improve students' weak areas.

Other statements, such as "AI-based feedback has helped me improve the quality of my assignments and exams" (2.89, SD = 0.78) and "AI has assisted me in achieving my learning goals" (2.81, SD = 0.82), further demonstrate that PhotoMath effectively supports students in achieving academic milestones. Meanwhile, the statement "AI has helped me prepare for exams more effectively" received the lowest mean score of 2.72 (SD = 0.91), though it remains within the High level, indicating room for improvement in this aspect.

Overall, the results suggest that PhotoMath plays a significant role in enhancing students' academic performance by providing personalized feedback, tailored assessments, and targeted support for areas of weakness. These findings reinforce the potential of AI tools like PhotoMath to enhance learning outcomes and contribute to academic success in mathematics.

According to the fact that PhotoMath "has contributed to improving my academic performance," this argues the most for CLT (Sweller et al., 2019). PhotoMath lets all these students avail an improved cognitive resource for deeper learning and understanding of mathematical concepts by effectively reducing extraneous cognitive load through simplifying complicated computations and providing an entire answer step-by-step. Thus, such improved cognitive processing is likely to lead to improved academic performance. The findings also strongly support the Information Processing Theory. The statements "AI-powered tools have helped me identify and address my weaknesses in specific subjects" and "AI-based feedback has helped me improve the quality of my assignments and exams" align with the theory's emphasis on how learners acquire, organize, and store information (Loc et al., 2019). By providing targeted feedback and identifying areas for improvement, Photomath likely enhances students' ability to identify and address their knowledge gaps, leading to improved learning outcomes.

Furthermore, the evidence gathered completely affirms the Instrumental Theory. Since it directly expresses the instrumental value of PhotoMath as a tool to augment learning performance, the phrase "AI has made me better in terms of academic performance" is appropriate. PhotoMath enables students to realize their academic dreams as previously predicted by Instrumental Theory, since it affords students effective tools in dealing with mathematical problems, understanding conceptions, and knowing what areas to work on.

These results are in line with similar studies that have ascertained how application use, such as Photomath, positively affects performance and engagement among students (Saundarajan et al., 2020; Zain et al., 2023; Amparo et al., 2022). Findings from studies show that PhotoMath actually enhances academic performance, contributes to identifying and rectifying weaknesses, and makes assignments quality. These coincide with what has been found in the research mentioned above.

**Motivation**

This section examines the impact of PhotoMath on the motivation of senior high school students to learn mathematics. It evaluates how the app impacts students' drive, confidence, and eagerness to engage with mathematical concepts and solve problems. The focus is on how PhotoMath promotes a positive outlook toward mathematics by breaking down complex problems, offering immediate feedback, and enhancing the learning experience. By examining its influence on motivation, this section aims to shed light on how PhotoMath inspires students to maintain interest and take an active role in improving their mathematical skills.

Table 7 displays the student-perceived impact of PhotoMath on their motivation, including insights into progress tracking, gamified learning, feedback and recognition, peer connection, and goal-setting.

It also shows the weighted mean, median, standard deviation, and level of impact for each statement related to PhotoMath's influence on student motivation.

Table 7  
Impact of PhotoMath (Motivation)

Statements	Weighted Mean	Median	SD	Level of Impact
Motivation				
1. AI has provided insights and progress tracking to keep me motivated.	2.67	3.00	0.72	High
2. AI has provided opportunities for gamified learning, making the process more enjoyable and engaging.	2.56	3.00	0.81	High
3. AI has offered feedback and recognition for my achievements.	2.64	3.00	0.93	High
4. AI has connected me with peers who share similar goals and interests.	2.19	2.00	0.82	Low
5. AI has facilitated goal-setting and action planning for academic success.	2.50	2.50	0.85	Low
<b>Overall Rating</b>	<b>2.51</b>	<b>3.00</b>	<b>0.84</b>	<b>High</b>

Legend: 3.26-4.00 Very High, 2.51-3.25 High, 1.76 – 2.50 Low, 1.00-1.75 Very Low

Table 7 highlights the perceived impact of PhotoMath on the motivation of students, with an overall rating of 2.51 (SD = 0.84), indicating a High level of impact. This suggests that students view PhotoMath as a helpful tool in fostering their academic motivation.

The highest-rated statement, "AI has provided insights and progress tracking to keep me motivated," received a weighted mean of 2.67 (SD = 0.72), reflecting students' appreciation of PhotoMath's ability to monitor their progress and encourage them to continue striving toward their goals. Similarly, the statement "AI has offered feedback and recognition for my achievements" was rated highly at 2.64 (SD = 0.93), emphasizing the importance of feedback in motivating students.

The statement "AI has provided opportunities for gamified learning, making the process more enjoyable and engaging" was also rated highly, with a weighted mean of 2.56 (SD = 0.81). This highlights the value students place on engaging and interactive features that enhance the learning experience.

In contrast, the statement "AI has connected me with peers who share similar goals and interests" received the lowest mean score of 2.19 (SD = 0.82), indicating a Low level of impact. This suggests that students perceive a gap in the app's ability to foster peer collaboration and connectivity. Similarly, "AI has facilitated goal-setting and action planning for academic success" received a weighted mean of 2.50 (SD = 0.85), placing it at the border of High and Low impact, suggesting room for improvement in this area.

Overall, the results suggest that PhotoMath significantly impacts students' motivation by providing insights, feedback, and gamified learning opportunities. However, enhancing features related to peer collaboration and goal-setting could further improve its motivational benefits. These findings reinforce the potential of AI-powered tools like PhotoMath to support and inspire students in their academic journey.

The findings align well with Self-Determination Theory (Deci & Ryan, 2000). Emphasis on "insights and progress tracking," "feedback and recognition," and "gamified learning" typically promotes basic psychological needs important for intrinsic motivation, such as autonomy, competence, and relatedness. Although not directly tied to motivation, the observation that "AI has offered insights and progress tracking to maintain my motivation" indirectly aligns with CLT (Sweller et al., 2019). By delivering clear and straightforward feedback, PhotoMath assists students in recognizing and correcting their misunderstandings promptly. This can alleviate the cognitive overload that comes with grappling with challenging concepts, allowing for more mental capacity to engage in deeper learning and problem-solving.

The findings are in line with studies showing that PhotoMath can enhance student engagement and motivation (for instance, Zain et al., 2023). Feedback, progress tracking, and game-like learning elements correspond to the positive effects of the other studies that suggest PhotoMath can boost children's interest and enjoyment of math.

### Self-reliance

This section discusses the impact of PhotoMath on the self-reliance of Grade 11 students in mathematics. Self-reliance, defined in this study as students' ability to independently and effectively apply mathematical concepts and problem-solving techniques following their use of PhotoMath, is essential for developing independent learning skills and confidence. This section aims to assess how PhotoMath supports students in becoming more capable of tackling mathematical challenges on their own, reducing dependence on external assistance.

Table 8 presents the data on the perceived impact of PhotoMath on the self-reliance of Grade 11 students in mathematics. This table highlights the extent to which students have developed the ability to independently apply mathematical concepts and solve problems after using PhotoMath. The analysis focuses on key indicators of self-reliance, providing insights into how PhotoMath contributes to fostering autonomy and confidence in mathematical problem-solving.

Table 8  
Impact of PhotoMath (Self-reliance)

Statements	Weighted Mean	Median	SD	Level of Impact
Self – reliance				
1. AI-powered tools have supported my ability to think critically and solve problems on my own.	2.67	3.00	0.72	High
2. AI has enhanced my confidence and self-reliance in academic pursuits.	2.56	3.00	0.73	High
3. AI has encouraged reflective thinking and self-evaluation of my learning progress.	2.64	3.00	0.72	High
4. AI has provided resources and tools for self-assessment and self-improvement.	2.83	3.00	0.70	High
5. AI has helped me develop self-discipline and accountability in my studies.	2.67	3.00	0.86	High
6. AI has encouraged self-directed learning and exploration of topics beyond the curriculum.	2.89	3.00	0.75	High
<b>Overall Rating</b>	<b>2.71</b>	<b>3.00</b>	<b>0.75</b>	<b>High</b>

Legend: 3.26-4.00 Very High, 2.51-3.25 High, 1.76 – 2.50 Low, 1.00-1.75 Very Low

Table 8 outlines the impact of PhotoMath on the self-reliance of Grade 11 students in mathematics, with an overall rating of 2.71 (SD = 0.75), signifying a High level of impact. This indicates that PhotoMath effectively promotes students' independence in learning and problem-solving.

The statement "AI has encouraged self-directed learning and exploration of topics beyond the curriculum" received the highest rating, with a weighted mean of 2.89 (SD = 0.75). This highlights the app's ability to inspire students to explore and learn beyond the standard curriculum, fostering a deeper and more autonomous approach to education.

The statement "AI has provided resources and tools for self-assessment and self-improvement" also rated highly, with a weighted mean of 2.83 (SD = 0.70), underscoring the usefulness of PhotoMath in enabling students to evaluate their own performance and address areas needing improvement independently.

Statements such as "AI-powered tools have supported my ability to think critically and solve problems on my own" and "AI has helped me develop self-discipline and accountability in my studies" both scored 2.67 (SD = 0.72 and 0.86, respectively), emphasizing PhotoMath's role in nurturing critical thinking, self-discipline, and personal accountability among students.

Additionally, the statement "AI has encouraged reflective thinking and self-evaluation of my learning progress" received a weighted mean of 2.64 (SD = 0.72), indicating that students value the app's ability to help them reflect on their academic progress and identify areas for growth.

The lowest-rated statement, "AI has enhanced my confidence and self-reliance in academic pursuits," garnered a weighted mean of 2.56 (SD = 0.73). While still within the High impact range, this suggests that PhotoMath's role in boosting confidence and self-reliance could be further strengthened.

Overall, the results show that PhotoMath significantly supports the development of self-reliance among students by fostering independent learning, critical thinking, and reflective practices. Its ability to encourage exploration beyond the curriculum and provide practical self-assessment tools solidifies its value in promoting autonomy. However, there remains an opportunity to enhance its impact on students' confidence in academic settings.

The findings are closely aligned with Self-Determination Theory (Deci & Ryan, 2000). The focus on "self-directed learning," "self-assessment," "critical thinking," "self-discipline," and "reflective thinking" highlights the importance of meeting the basic psychological needs for autonomy and competence, which are essential for fostering intrinsic motivation and self-reliance. By promoting independent exploration, offering tools for self-assessment, and encouraging critical thinking, Photomath enables students to take charge of their learning and cultivate the skills needed for independent study. The fact that Photomath stimulates "a provoke for exploration of topics beyond the curriculum" is in accordance with Situated Learning Theory (Lave; Wenger, 1991). Because of this, Photomath enables the whole exploration beyond the regular curriculum by evicting space for students to correlate their learning to real-life conditions while also giving a more thorough understanding of mathematics.

The findings are consistent with related studies that have shown Photomath can enhance student autonomy and self-reliance (Saundarajan et al., 2020; Riski et al., 2021). The emphasis on independent learning, critical thinking, and self-assessment aligns with the positive impacts observed in these studies. Avanda & Putri (2020) observed that although many students recognized and utilized the PhotoMath application, they viewed it as just a regular tool and raised worries about its ability to encourage laziness. This aligns with the finding that highlights the necessity of boosting students' confidence and self-reliance, suggesting that while applications like PhotoMath can be helpful, there is still potential for better integration into educational practices.

Zain et al. (2023) demonstrated that the utilization of PhotoMath in algebra classes can significantly influence increased achievement among students and boost interest in the subject area. This also goes hand in hand with findings regarding the role PhotoMath plays in developing critical thinking and personal responsibility because enhanced engagement in learning is usually concomitant with improved academic performance and greater ownership of learning. Moreover, Dewi et al. (2023) showed that PhotoMath is a valuable tool for students tackling mathematical problems in a range of subjects, including advanced calculus. This aligns with the conclusion that PhotoMath offers resources for self-assessment and improvement, enabling students to review their solutions and gain a better understanding of the problem-solving process.

#### AI dependency

This section explores the impact of PhotoMath on AI dependency in Grade 11 students' mathematics learning. AI dependency is defined as the extent to which students rely on artificial intelligence tools, such as PhotoMath, to solve math problems and complete tasks. It highlights the balance between using technology for assistance and maintaining independent problem-solving skills. By examining students' reliance on PhotoMath, this section aims to assess its impact on learning autonomy and the development of mathematical competence.

Table 9 presents the results concerning the influence of PhotoMath on AI dependency among Grade 11 students in mathematics. It includes statistical measures such as the standard deviation, weighted mean, median, and level of impact. These figures provide a detailed analysis of how much students rely on PhotoMath, offering insights into the balance between using technology for assistance and maintaining independent problem-solving skills. The data shown in this table is crucial for understanding the effects on learning independence and the development of mathematical proficiency.

Table 9  
Impact of PhotoMath (AI Dependency)

Statements	Weighted Mean	Median	SD	Level of Impact
AI dependency				
1. I feel more confident and capable with the assistance of AI in my studies.	2.56	3.00	0.88	High
2. I heavily rely on AI tools to support my study-related activities.	2.03	2.00	0.81	Low
3. AI has significantly influenced my educational choices and decision-making processes.	2.31	2.00	0.75	Low
4. AI has transformed the way I approach learning and problem-solving tasks.	2.53	3.00	0.91	High
5. I believe AI has positively impacted my overall educational journey.	2.72	3.00	0.91	High
6. I feel that AI has improved the quality of my learning outcomes.	2.69	3.00	0.86	High
7. AI has become a trusted source of information and guidance for me.	2.58	3.00	0.87	High
8. I actively seek out AI-powered tools and resources to enhance my learning experience.	2.47	3.00	0.77	Low
9. AI has increased my efficiency and productivity in academic tasks.	2.86	3.00	0.83	High
<b>Overall Rating</b>	<b>2.53</b>	<b>3.00</b>	<b>0.87</b>	<b>High</b>

Legend: 3.26-4.00 Very High, 2.51-3.25 High, 1.76 – 2.50 Low, 1.00-1.75 Very Low

Table 9 highlights the perceived impact of PhotoMath on students' AI dependency, with an overall rating of 2.53 (SD = 0.87), indicating a High level of impact. This suggests that students consider PhotoMath a valuable tool in supporting their academic activities and enhancing their learning experience.

The highest-rated statement, "AI has increased my efficiency and productivity in academic tasks," received a weighted mean of 2.86 (SD = 0.83), reflecting students' recognition of PhotoMath's role in streamlining their academic processes. Similarly, the statement "I feel that AI has improved the quality of my learning outcomes" was rated highly at 2.69 (SD = 0.86), emphasizing the tool's ability to enhance the quality of students' learning. Another highly rated statement, "I believe AI has positively impacted my overall educational journey," scored 2.72 (SD = 0.91), highlighting the broader educational benefits of PhotoMath.

Meanwhile, the statement "I heavily rely on AI tools to support my study-related activities" received the lowest mean score of 2.03 (SD = 0.81), indicating that students exhibit limited dependence on AI tools for routine academic tasks. Similarly, the statement "AI has significantly influenced my educational choices and decision-making processes" was rated at 2.31 (SD = 0.75), suggesting a moderate impact on students' strategic decision-making. Lastly, "I actively seek out AI-powered tools and resources to enhance my learning experience" scored 2.47 (SD = 0.77), reflecting a relatively lower level of engagement with AI tools outside PhotoMath.

Overall, the results suggest that PhotoMath plays a significant role in enhancing students' productivity, learning quality, and overall educational experience while maintaining a balanced level of reliance. These findings highlight the potential of AI tools like PhotoMath to support academic growth without fostering excessive dependency.

The observation that PhotoMath "has boosted my efficiency and productivity in academic tasks" aligns well with Cognitive Load Theory (Sweller et al., 2019). By automating basic calculations and offering detailed solutions, PhotoMath lessens the cognitive load involved in tackling math problems. This enables students to focus more on grasping concepts, honing problem-solving techniques, and pursuing a deeper understanding of the material.

According to Williams (2020), students use digital applications such as PhotoMath for checking answers, boosting their confidence, and deepening their understanding of mathematics. This is consistent with the finding that PhotoMath complements

efficiency and productivity in academic work enjoyed by students seeing its contributions toward streamlining the whole academic process. Also, Dewi et al. (2023) showed that using PhotoMath greatly helps students tackle mathematical problems and enhances their learning results. This aligns with the observation that students believe PhotoMath has enriched the quality of their learning experiences.

A study by Todoranova and Penchev (2019), explains that PhotoMath works effectively to solve problems, it does not in any way mean that students tend to seek out or use other AI resources as extensions to PhotoMath; in fact, it indicates more of a low engagement with other AI tools that could be used to enhance learning.

As Nguyen Phu Loc and team (2019) discussed, educational tools like PhotoMath could cause students to change their decision-making processes but should not overly rely on them, as this may impede the formation of problem-solving strategies and retaining knowledge. The impacts on educational choices and students' decision-making processes are thereby supported. It also supported by the study conducted by Todoranova & Penchev (2019) pointed out that although PhotoMath is useful for solving problems, students often do not look for other AI-powered resources beyond it. This indicates a somewhat limited engagement with additional AI tools that could enhance their learning experience.

## **CONCLUSION AND RECOMMENDATIONS**

Based on the findings of the study, the students reported significant benefits in multiple areas, including enhanced learning experiences, improved academic performance, increased motivation, greater self-reliance in mathematics, and reduced reliance on AI tools. These results suggest that PhotoMath is an effective tool for improving students' mathematical competence, supporting the need for an updated delivery plan that incorporates such technological tools to enhance the learning process.

In light of the findings of the study, it is highly recommended that the existing delivery plan be updated by integrating the PhotoMath application to enhance the performance level of the Grade 11 learners in General Mathematics. The following recommendations may help maximize the benefits of PhotoMath in enhancing students' mathematical competence while addressing potential challenges in its integration into classroom instruction.

Teachers may consider integrating PhotoMath into classroom activities to supplement traditional instruction, focusing on areas where students tend to struggle. Additionally, a blended teaching strategy combining manual problem-solving and PhotoMath usage may be implemented to further improve student performance. Educational institutions may adopt PhotoMath as a supplemental learning tool in their mathematics curriculum. To maximize its potential, professional development sessions for teachers on effectively integrating PhotoMath into lesson delivery may be conducted. Educational institutions may consider incorporating PhotoMath into their instructional strategies to enhance students' learning experiences, academic performance, and motivation. Teachers may utilize PhotoMath to design interactive and engaging activities that promote self-reliance and critical thinking while ensuring alignment with curriculum goals. To address the potential for over-reliance on technology, measures such as periodic assessments without technological aids may be implemented to strengthen students' mathematical reasoning skills. By promoting a balanced use of PhotoMath, educators may foster a supportive yet challenging learning environment that maximizes its benefits while minimizing dependency on AI tools.

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