

The effect of interactive AI tools like photomath on developing mathematical concepts in students with learning difficulties: A quasi-experimental study



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Abstract The Effect of Interactive AI Tools like Photomath on Developing Mathematical Concepts in Students with Learning Difficulties: A Quasi-Experimental Study represents a transformative shift in educational practices. By leveraging AI technologies, educators can tailor learning experiences to meet individual student needs, facilitating a more inclusive environment for those who may struggle with traditional teaching methods. This article to investigate the impact of artificial intelligence (AI) applications on development of mathematical concepts among primary-stage students with learning difficulties, Methods A quasiexperimental design was used, and participants were divided into two groups: an experimental group (30 students) taught with AI applications and a control group (30 students) taught with traditional methods. A test to measure mathematical concepts was developed, ensuring its reliability and validity. The findings highlighted a significant positive effect of AI applications, such as Photomath, on the development of mathematical concepts among students with learning difficulties, with the experimental group outperforming the control group. The negative impact that is detrimental to students is the potential for academic cheating and decreased interest in studying mathematics due to dependence on using Photomath. Overall, it is hoped that this research can fill the gap in knowledge and unlock research potential in the field of Photomath mathematics learning This indicates that easy access to Photomath can improve mathematics learning outcomes for this group of students by providing an interactive environment that supports their understanding of mathematical concepts. Although the majority of findings point to the positive impact of using Photomath, it is essential that teachers and other educational personnel undergo training to ensure the optimal use of this application in teaching students with learning difficulties. This study highlights the importance of integrating AI applications into the curriculum, particularly for teaching mathematics to students with learning difficulties. This study recommends providing training programs for teachers to increase their ability to use AI applications effectively to support students' learning.

Keywords: artificial intelligence, applications mobail, mathematical concepts, photomath, learning, learning difficulties

1. Introduction

Recent decades have witnessed an enormous boom in the digital revolution and have contributed to radical changes in various fields, most notably, the education sector, where technological and digital tools have become an integral part of the educational process, contributing to improving the efficiency and effectiveness of education and moving education from a limited traditional environment to interactive educational spaces characterized by inclusiveness and innovation.

The integration of Artificial Intelligence (AI) in education has become increasingly significant, particularly for students with learning difficulties in mathematics. Historically, the role of AI in educational contexts began in the 1960s, evolving through various phases, including intelligent tutoring systems in the 1980s, which marked a crucial advancement in personalized learning experiences (Vieriu & Petrea, 2025). Today, AI technologies are characterized by their ability to adapt educational content to suit individual learners' needs, thereby fostering more inclusive educational environments (Bani Ahmad et al., 2023). Among the most important shifts are the changing role of the teacher, which is no longer limited to the transfer of knowledge but has become a guide and facilitator of the learning process, and in the field of special education for the teacher, a pivotal role in integrating applications and tools of artificial intelligence in the education of people with learning difficulties (Thurzo et al., 2021). These applications provide interactive features in learning environments and feedback, helping learners better understand and retain knowledge and enabling them to engage in practice and experiential learning (Lu & Lou, 2024).

One of the most prevalent groups of people with special needs includes learning difficulties, as they include a wide range of problems that affect the student's ability to acquire basic academic skills such as reading, writing and arithmetic (Ali et al., 2024). Learning disabilities affect the cognitive and developmental abilities of students, which leads to noticeable



challenges in the process of learning and acquiring knowledge. Abstract scientific concepts are an obstacle to the learning of students in general and students with learning disabilities in particular (Hibi, 2024), as they focus on developing logical thinking and the ability to solve problems, so they require abstract understanding and advanced mental skills (Wardat et al., 2024).

The integration of artificial intelligence (AI) in mathematics education has stimulated many research initiatives at the international level (Opesemowo, 2024), and for people with learning disabilities, AI overcomes the challenges they face and makes tangible progress in mastering mathematics learning (Garg, 2020). The study of Najadat & Obeidat. (2024) confirmed the effectiveness of artificial intelligence techniques in their ability to positively affect the processes of early diagnosis and therapeutic intervention for children with special needs. Artificial intelligence systems allow for customized educational activities and (Smith & Smith, 2021) confirm that they consider individual differences between students and analyze educational performance continuously according to the needs of students.

Wardat et al. (2024) reported that mathematical concepts aim to enhance students' understanding of basic mathematical concepts and to develop their ability to think analytically and abstractly with various educational strategies. With the increasing use of Artificial Intelligence (AI) applications in light of the rapid advancements in the digital era, these applications have become an integral part of the educational process (Shou et al., 2021). These applications assist students in fostering creativity and differentiation in learning, particularly in interactive learning environments such as the metaverse (Al-Nawaiseh et al., 2023). The presence of AI also supports educational staff, such as teachers, in administrative tasks and optimizing the teaching of mathematics. Ahmad et al. (2023). Additionally, AI applications have contributed to creating an interactive learning environment by simulating human learning processes such as learning, predicting, and decision-making. This enables students in general, and students with learning difficulties in particular, to master abstract scientific concepts more effectively (Chen et al., 2020).

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Some AI applications, particularly those utilizing interactive multimedia, offer substantial support in enhancing students' creative processes (Tejawiani et al., 2023). A notable AI product that has been widely adopted is the ChatGPT website, which has been recognized as an effective tool for improving students' learning abilities (Wardat et al., 2023). Studies indicate that ChatGPT is capable of solving mathematical problems accurately, which contributes to enhancing students' understanding of mathematical concepts. Therefore, it can be concluded that the integration of AI has brought transformative changes in the way students learn and interact with mathematical concepts. Among the various AI-driven mathematics learning applications, Photomath is considered the most influential, according to empirical research findings. Derianto et al. (2023). Saundarajan et al. (2020).

The problem of the study is the low ability of students with learning disabilities to master mathematical concepts, as they are numbers and abstract ideas and have limited cognitive ability (Thurzo et al., 2021). The weakness of students with learning disabilities lies in their ability to acquire, retain and remember the information provided to them in the classroom (Najadat & Obeidat, 2024). While teachers support students with learning difficulties in the classroom, the study (Garg, 2020) highlighted the importance of adopting artificial intelligence techniques in schools to reduce the gap between students with learning difficulties and their colleagues. It also supports the integration of artificial intelligence in education to achieve educational justice. Qawaqneh et al. (2023)

Through the researchers' work environment, it was noted that students who face challenges in mathematical concepts are often the most in need of individualized and ad hoc support, and this was confirmed by interviews with mathematics teachers for the category of students with learning difficulties. On the basis of the results of the interviews, mathematics teaching is still currently ineffective. Some of the reasons why students have difficulty understanding how to solve problems. and how to complete examples of difficult questions, but students can still ask easy questions. In addition, math is learned face-to-face to help students understand difficult mathematical concepts more easily. To maximize learning outcomes, it takes the teacher longer, while the teacher's time teaching math in the classroom is limited to only 4 hours in one week.

As confirmed by (Xu et al., 2021) The Photomath app is available for Android, iOS, and Windows Phone devices, allowing users to solve math problems by taking a picture or entering the text of the problem, Apart from providing answers to math questions, Photomath also provides complete and accurate discussions and solution steps. To date, Photomath can handle various types of math problems, including decimals, fractions, arithmetic, geometry, and simple linear equations (Zain et al., 2023). This is very helpful in independent learning and reduces students' dependence on the help of teachers or tutors (Gocen & Aydemir, 2020) (Voskoglou & Salem, 2020).

Photo math has been shown to teach students mathematical learning difficulties. Photo Math has the ability to carry out tasks that require human intelligence, facilitate the analysis of mathematical problems and clarify abstract concepts at high

speed (Jin et al., 2023). The application works through the student's phone so that he can view the computer screen, which provides immediate solutions to mathematical problems. Photo math can recognize and solve mathematical equations. Provide step-by-step explanations to help users understand the problem-solving process. Using photo math to learn math has many advantages and benefits for students. It enables the study members to learn on their own from the Photo Math application by writing the questions clearly and accurately on paper and then taking pictures of them. After the results appear, they are copied while understanding the steps included in the application at the same time. Using the app can also be helpful for students in manually correcting the student questions that they answer. To improve the level of students' understanding of mathematical concepts such as basic calculations, numerical relationships, and mathematical patterns, which are measured by the degree of improvement of students in the mathematical concepts test that the researcher will prepare for this purpose.

study (Garg, 2020) confirmed the analysis of how artificial intelligence affects the education of students with special needs. The data collection was based on qualitative research conducted via focused interviews with teachers and students with special needs. The data were collected from the literature in the EBSCO academic databases, which consist of Web of Science, Scopus, Science Direct, newspapers, magazines and blogs. The responses obtained via content analysis were analyzed, and the results revealed that artificial intelligence has an impact on the education of people with special needs and that it contributes to helping teachers promote the education of people with special needs. The results of the study of Franselaa dan Rangkuti (2019) indicate that the implementation of math learning with the help of the Photo Math emetics application is carried out via the steps of using a cell phone camera for Photo Math emetics to see the answers to the math exam questions during the study, starting with writing the questions, taking pictures, and writing the answers displayed on the screen of the Photo Math emetics mobile application.

The current study contributes to bridging the knowledge gap related to the use of artificial intelligence in education and provides insights into best practices that can be adopted to develop educational curricula and methods. AI-based learning tools that can be used in classrooms to simplify mathematical concepts and make them more engaging and interactive should be introduced.

The current study aims to reveal that there are statistically significant differences at the level of significance ($\alpha \leq 0.05$) between the average scores of students with learning difficulties in the basic stage in the experimental and control groups in the postmathematical concepts test attributed to the teaching method (photo math application/the usual method).

1.1. By answering and verifying the following hypothesis

Are there statistically significant differences at the level of significance ($\alpha \leq 0.05$) between the average scores of students with learning difficulties in the basic stage in the experimental and control groups in the postmathematical concepts test attributed to the teaching method (photo math application/regular method)?

2. Materials and Methods

The semiexperimental approach was adopted to suit the purposes of the study, as this approach is the most appropriate for measuring the impact of the use of artificial intelligence applications in the development of mathematical concepts among students with learning difficulties.

2.1. The study sample

Consisted of (60) male and female students from the basic stage (third grade) in one of the private schools for the academic year (202 4-202 5) due to the availability of the technological infrastructure necessary for artificial intelligence applications and the cooperation of the school administration and mathematics teachers with the researcher. The study members were divided into two groups: the first group was an experimental group, and the second group was a control group; each group included (30) students. The experimental group will study using the photo math application in teaching mathematical concepts, whereas the control group will study in the usual way.

2.2. Study tool

A test has been developed to measure the mathematical concepts of students with learning disabilities and to adopt the photo math application, which is available for free and can be easily installed on mobile devices.

2.3. Study design and variables

The study adopts the design of two unequal groups (pre- and posttest). The experimental group will study using artificial intelligence applications, whereas the control group will study in the usual way. The study includes the following variables:

- Independent variable: use (photo math application/standard method).
- Dependent variable: Development of mathematical concepts.

2.4. Statistical processing

The data were analyzed statistically via arithmetic averages and standard deviations, the t test was applied to two independent samples, and the size of the trace was calculated via the eta-square coefficient (η^2) to determine the effectiveness of the application of photo math in the development of mathematical concepts.

The teaching process took place during the first semester of 2024–2025 and included the following stages:

- Planning phase: This phase starts by identifying the Photo Math application and downloading it on the Android devices of teachers and students.
- The implementation phase: This phase includes writing questions, taking and scanning pictures of questions, finding solutions and steps via photo math, copying questions, working on training questions, and evaluating/correcting.
- Assessment: Learning outcomes in math with the help of Photo Math showed good success, as students were able to solve problems well.
- Challenges/Constraints: Challenges included the difficulty of applying to students who do not own Android devices, making some students only copy answers without understanding.

3. Results and Discussion

This section presents the results of the study according to the statistical analysis via SPSS, discusses the results, presents them in a sequential manner, and presents appropriate recommendations and proposals according to the results of the study as follows:

question

Are there statistically significant differences at the level of significance ($\alpha=0.05$) between the arithmetic means of the scores of the experimental and control groups in the test of mathematical concepts attributed to the teaching method (photo math application) versus the usual method?

To answer this question, the arithmetic means and standard deviations of the grades of the third-grade students were calculated on the test of mathematical concepts in the pre- and postintervention measurements according to the teaching method (photo math application, regular), as shown in Table 1:

Table 1 Arithmetic means and standard deviations of the grades of the third-grade students on the test of mathematical concepts for the pre- and postintervention measurements according to the method of teaching (photo math application, regular).

Teaching Modality	Nos.	Pre-Test		Posttest	
		Mean	Standard Deviation	Arithmetic Mean	Standard Deviation
AI applications	30	53.50	673	71.50	036
Routine (R3)	30	49.83	0.964	55-17-140	11.332

It is clear from Table 1 that there are apparent differences between the arithmetic circles of the grades of the primary third-grade students on the test of mathematical concepts in the pre- and post-measures according to the teaching method (photo math application, regular). In the premeasurement, the results were similar between the two groups. The arithmetic mean of the photo math application group was 53.50, and that of the regular group was 49.83, with a standard deviation similar to that of both groups. In the postmeasurement, there was a clear improvement in the performance of the students who studied via the photo math application, as its average score increased to 71.50 compared with the average score of the regular group, which was 55.17. To determine whether these apparent differences are statistically significant, one-way ANCOVA was used for the postmeasurement to test mathematical concepts as a whole according to the teaching method (photo math application, regular) after neutralizing the impact of their premeasurement. The following is a presentation of these results, as shown in Table 2:

Table 2 Results of One-Way ANCOVA for Tenth-Grade Students' Post-Test Scores on Mathematical Concepts.

Source of Variance	Sum of Squares	Degrees of freedom	Sum of Squares	Value Feddan	Significance level	ETA square η^2
Pre-Test	152	1	152	330	.000	.653
Teaching Modality	983	1	983	182	.000	\$.395.
Error	515	57	-0.044			
Nephrology	15183.333	59				

There are statistically significant differences at the level of significance ($0.05=\alpha$) in the grades of the primary third-grade students on the test of mathematical concepts according to the teaching method (photo math application, regular). For the pretest measurement, the total squares reached 7303.152 with one degree of freedom, which reflects the variation in performance between students before applying different teaching methods. The average sum of squares was (7303.152), which is a high value, which led to a statistically significant value of (107.330) at the level of (0.000), which means that there are statistically significant differences due to the premetering, and the square of η^2 (0.653), which indicates that the premetering explains approximately 65.3% of the total variance in the results.

For the teaching method, the total squares reached 2529.983 with one degree of freedom, which resulted in an average total square of 2529.983 and a value of 37.182, which was statistically significant at the level of 0.000, indicating that the



teaching method had a statistically significant effect on the performance of the students. It is also clear from Table 2 that the size of the impact of the teaching method was significant; the value of the square of η^2 explained (39.5%) the interpreted variance (predicted) in the dependent variable, which is the test of mathematical concepts, and the total squares of error amounted to (3878.515) degrees of freedom (57), which gives an average total square of (68.044). The total discrepancy was 15183.333 degrees of freedom (59), reflecting the total discrepancy in the results. These results clearly indicate that pretesting and teaching methods had a strong and statistically significant effect on student outcomes.

To determine which differences are attributable, the adjusted arithmetic averages and their standard errors were extracted according to the teaching method, as shown in Table 3.

Table 3 Adjusted Means and Standard Errors of Mathematical Test Scores by Teaching Method.

Teaching Modality	Adjusted Dimensional Arithmetic Average	Standard error
AI applications	895	1.514
Routine (R3)	.771	1.514

The results in Table 3 show the adjusted arithmetic means and the standard errors of the total score of the test of mathematical concepts after adjusting for the effect of prescaling. According to the teaching method used, for the method of applying photo math, the adjusted postarithmetic mean was 69.895, with a standard error of 1.514, which indicates a significant improvement in the performance of students who underwent teaching via the photo math application. This high average reflects the effectiveness of the method in enhancing the acquisition of mathematical concepts. In contrast, the usual method resulted in a lower average score (56.771) with the same standard error (1.514). This difference between the two methods clearly reflects the superiority of the AI application method, as the students in this group performed better after adjusting for other variables.

The positive results in the study for students with learning difficulties are attributed to the fact that Photomath processes mathematical data in the form of images and textual questions. It provides step-by-step explanations of equations and abstract mathematical concepts, including word problems. This aligns with the findings of Aisyah (2024). Given the specific needs of students with learning difficulties, Photomath offers mathematical solutions in various ways, thanks to its interactive features and visual aids that assist students in completing their math assignments (Wulandari, 2024). Photomath is considered an enhancement to math learning outcomes, according to a study by Zain et al. (2023). as it can be widely used to help students when they are at home without a reference to turn to.

In particular, students with learning difficulties generally require special strategies in all academic subjects, especially in mathematics, which demands deeper thinking skills. Photomath provides the appropriate interactive environment, as indicated by Bukhatwa (2024), Daguinotan et al. (2024), and Igcasama et al. (2020). Additionally, Photomath helps analyze student performance continuously, identifying strengths and weaknesses, allowing teachers the flexibility to adapt the content to meet the needs of these students. This is in agreement with Nurlaelah et al. (2024). To overcome the challenges faced by students with learning difficulties in following regular lessons, which are presented uniformly to all students without considering individual differences, Photomath offers flexible content that can be adjusted to the student's learning progress, reducing frustration and enhancing motivation to learn (Booc et al., 2023)

In addition, photo math is distinguished by its ability to provide a stimulating and interactive learning environment. It relies on techniques such as animation, educational games and immediate feedback, which make the learning process more enjoyable and effective. This method enhances students' focus and increases their active participation, which is necessary for students with learning difficulties, who tend to lose focus quickly with the usual methods. Photo math creates a nondull learning environment, where the student feels accomplished when making tangible progress through notifications and positive feedback provided by these applications. As Yolandasari et al. (2022) suggested, the use of photo math affects students' ability to understand mathematical concepts, and the results suggest that teachers should be able to use photo math-based media in math lessons.

On the other hand, the feedback provided by the photo math application is a pivotal factor in its superiority over the usual methods. The applications provide immediate and accurate feedback about the student's performance after each step or exercise, which helps him understand his mistakes and work to correct them in a timely manner. This characteristic is very important for students who may not realize their mistakes in a timely manner during traditional education. Moreover, the feedback in the photo math application provides personal support similar to the presence of a special teacher for each student, which makes him or her feel interested and continuous support.

Students with learning disabilities also respond better when information is presented in multiple sensory ways, that is, visual, auditory, and motor means are used. Artificial intelligence applications rely on integrating these methods in a balanced manner. Mathematical concepts are explained through pictures and illustrations, in addition to the use of sounds and motor interactions. This integrated method enhances the students' ability to understand mathematical concepts and hold them in memory better than the usual methods, which rely mainly on verbal explanation only. (Aisyah, 2024)

Students with learning disabilities suffer from high levels of stress and anxiety when learning in regular classes as a result of being exposed to repeated failures or feeling less capable than their colleagues in the usual methods of education. Bryan

Booc et al. (2023) On the other hand, artificial intelligence applications provide a safe and stress-free learning environment. The student learns on his own, without fear of the views of others or direct criticism from the teacher, which reduces stress and increases his self-confidence. The application also provides education in an encouraging manner and at graduated levels, which gives the student the opportunity to learn at the pace that suits him This aligns with both (Kurnia et al., 2023)

The photo math application relies on providing intensive exercises and activities that are characterized by regular repetition, which is necessary for students with learning disabilities, who need more time and practice to understand mathematical concepts. Repetition is not boring, as usual methods do; rather, it is combined with fun and interactive methods that maintain the student's motivation. The application also follows the student's progress and directs the training toward the points that need improvement, which significantly contributes to improving his performance. The photo math application helps students develop independence and problem-solving skills. Rather than relying entirely on the teacher, the student learns how to explore information and solve exercises on his own through the application instructions. This enhances the student's self-confidence and develops his skills in critical and logical thinking, which are essential skills for understanding mathematical concepts. The student's self-reliance in learning makes him feel accomplished and proud, which increases his motivation toward learning. (Daguinotan et al., 2024)

Photo math is also an important tool for promoting collaborative learning among students, as it provides interactive virtual environments that enable students to work together to solve problems and exchange ideas, which improves their communication and teamwork skills. These applications allow students to participate in group activities on the basis of creative thinking, where roles are allocated to each student on the basis of their strengths and needs. It can also rely on virtual and augmented reality technologies to engage students in joint educational projects, which add a new dimension to interaction and help develop their social skills. Moreover, artificial intelligence applications can contribute to enhancing learning outside the classroom, as they allow students to pursue their learning at any time and from anywhere, making the educational process more flexible and inclusive. This feature helps students who have difficulties continuing to attend school because of their health or psychological conditions. In addition, the data collected by these applications can contribute to the improvement of the educational system in general by providing comprehensive insights into students' performance and educational needs. This approach helps to develop dynamic and efficient educational plans, which enhances the quality of education and provides fair and productive educational experience for all groups, The disadvantage of using the Photo Math emetics app is that some students do not want to think about learning how to solve problems correctly according to what is taught in the Photo math app. In addition, some answers related to photo math are inappropriate. Four solutions were obtained that conflict with the mathematics specialization in solving quadratic equations in optical mathematics applications (Meldi & Suratman, 2022).

The results of the study were consistent with the results of the Al-Matari study (2024) and the study of Bani Ahmad et al. (2023), whose results demonstrated the effectiveness of the use of simulation through artificial intelligence in improving concepts among students with learning disabilities. Garg's study (Garg, 2020) revealed that artificial intelligence has an impact on the education of people with special needs and that it contributes to helping teachers promote the education of people with special needs.

On the basis of the above, the superiority of the application of photo math in the development of mathematical concepts among students with learning difficulties can be explained by several educational, psychological and technical factors. These factors include the ability to customize learning to suit the needs of students, provide a stimulating and multisensory environment, and provide immediate and accurate feedback. These applications reduce stress and anxiety among students and enhance their independence and self-confidence, which makes them more effective than the usual methods. In light of rapid technological development, it has become necessary to integrate artificial intelligence applications into the educational process to meet the needs of all students, especially those in the category of learning difficulties, which require distinct and innovative educational strategies.

4. Conclusions

This study aimed to determine whether there are statistically significant differences at the significance level ($\alpha \leq 0.05$) between the average scores of students with learning difficulties in the basic stage in the experimental and control groups in the post-mathematical concepts test due to the teaching method (Photo Math application vs. the traditional method). The findings confirmed the presence of significant differences between the two groups, demonstrating the impact of AI-based educational tools on students' mathematical concept acquisition, Future research should explore the long-term effects of AI-based learning applications and investigate strategies to optimize their integration into educational settings. Educators and policymakers should consider incorporating AI-driven tools to support students with learning difficulties and enhance their overall learning experience, The use of AI in education has the potential to revolutionize traditional teaching methodologies by providing personalized, engaging, and efficient learning experiences. Future research should focus on refining these technologies, addressing their limitations, and exploring their long-term effects on student learning outcomes. Educators and policymakers should consider adopting AI-based tools as complementary resources to enhance student engagement, foster independent learning, and bridge the gap in mathematical concept acquisition for students with special needs.

5. Recommendations

On the basis of the results of the study, the researcher recommends the following:

- Educational institutions should adopt the use of artificial intelligence applications as part of the curriculum, especially in teaching mathematics to students with learning disabilities.
- Providing training programs for teachers to enhance their skills in using artificial intelligence applications effectively to support students.
- Developing intelligence applications adapted to the needs of students with learning disabilities, with a focus on multisensory learning strategies.
- Encourage further studies on the impact of AI applications in other educational fields.

6. Proposals for future studies

- Measuring the effectiveness of artificial intelligence applications in developing logical and analytical thinking skills among students with learning difficulties in the basic stage.
- Conducting studies on the use of artificial intelligence to provide customized mathematical content according to the level of learning difficulty for each student and its impact on understanding concepts.
- Conducting a study on the effectiveness of artificial intelligence applications in enhancing the mental calculation skills of students with learning disabilities.

Ethical considerations

In this research, data were collected through a questionnaire solely for scientific purposes. We ensured informed consent and confidentiality, while adhering to ethical guidelines. This approach safeguards participants' rights and enhances the integrity of our findings.

Conflict of Interest

The authors declare no conflicts of interest.

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