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Application of Artificial Intelligence Photomath in Learning Mathematics

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ABSTRAK

This article aims to summarize the research literature related to the development of research on the implications of Artificial Intelligence (Artificial Intelligence/AI) in mathematics learning. Most of the Empirical research shows that the use of AI has positive effects and helps spread mathematics learning, especially in the Photomath application. This research method uses a systematic literature review approach and reveals findings based on an empirical review of 45 articles from the Google Scholar database. The findings highlight that easy access to Photomath can improve mathematics learning outcomes. In addition, students can improve their mathematics achievement through interactive learning from this application. Although the majority of findings highlight the positive impact of using Photomath, however teachers and other educational personnel must undergo training so that the use of Photomath applications can be used for optimal teaching. 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.

Keywords: Artificial Intelligence, Mathematics Education, Photomath, Mathematics Application.

INTRODUCTION

In the digital era with rapid technological advances, the use of Artificial Intelligence (AI) is increasingly widespread, including in the field of education (Gocen & Aydemir, 2020; Xu *et al*., 2021). The existence of AI helps educational staff such as teachers in administrative matters and learning mathematics optimally (Xu *et al*., 2021). AI refers to a number of methods that enable machines to imitate human learning processes, such as learning, predicting, making decisions, and understanding the environment (Chen *et al*., 2020). Artificial intelligence (AI) can be applied in various applications such as machine learning, natural language processing, or image processing to assist in students' creative processes (Tejawiani *et al*., 2023). The AI product that is often found is the ChatGpt website which is considered to be able to improve students' learning abilities (Wardat *et al*., 2023). In fact, several studies state that ChatGpt can work on math problems with accurate results. So it can be concluded that the integration of artificial intelligence (AI) has brought transformative changes to the way students learn and interact with mathematical concepts. Among the various AI-driven mathematics learning applications, based on findings from empirical studies, the Photomath application is the most influential application (Derianto *et al*., 2023; Saundarajan, Osman, Daud, *et al*., 2020).

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 (Xu *et al*., 2021). 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). However, excessive use of

Photomath can cause students to feel dependent (Puji Rahayu *et al*., 2022; Rabiul Muzammil *et al*., 2023).

Based on this background, researchers are interested in analyzing the impact of Photomath on student learning outcomes for mathematics learning through a literature review. This research aims to explore various perspectives on the effectiveness of Photomath applications, as well as the challenges and opportunities they present. By exploring various existing literature sources, it is hoped that this research can provide a comprehensive picture of the benefits and limitations of using Photomath in mathematics learning.

RESEARCH METHODS

The research method in this article uses a systematic literature review approach with data sourced from Google Scholar. A systematic literature review is a data mapping technique that looks at the development of relevant research based on a period of time for further review. This method utilizes advanced text analysis capabilities through the VOSviewer application to help researchers understand and describe research situations in certain fields. The keywords used are "Application of Artificial Intelligence Photomath in Mathematics Learning" or "Application of Artificial Intelligence Photomath in Mathematics Learning" in the 2019-2024 period (see Figure 1). To capture relevant journal articles, researchers implemented research inclusion as follows:

a. Journal articles published in the 2019-2024 period
b. Journal articles can be fully accessed by researchers
c. Journal articles discuss the subject of Photomath in mathematics learning as an important component of the discussion.
d. Hanta data screening was carried out for the scientific writing category of research articles.

Initially, the researchers collected 60 journal articles that matched the keywords. However, after careful mapping, only 45 journal articles remained that were relevant in terms of title, abstract, keywords, and discussion. The development of research topics regarding the application of artificial intelligence Photomath in mathematics learning is as follows in Figure 1.

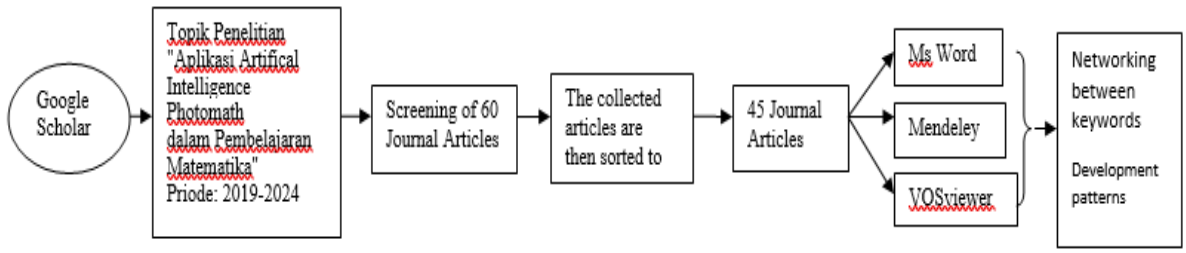

Figure 1. Research framework

Network Visualization

In this section, the author presents a visualization of the keyword network resulting from mapping 45 articles (see Figure 2). The clustering results show circles representing the number of occurrences of keywords simultaneously. Grouping was carried out using VOSviewer software with the final results showing 10 keywords that met the research topic criteria.

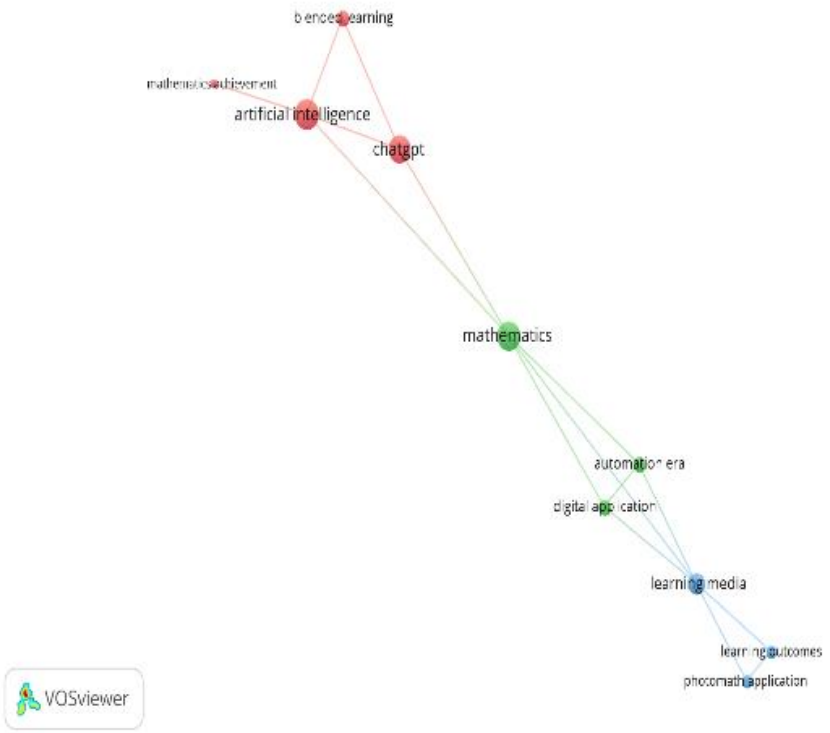

Figure 2. Distribution of research keywords

In the keyword network visualization above, we can see that the keywords "Artificial Intelligence" and "mathematics" are the main keywords in the research. This indicates that the topic of research on AI in mathematics learning has been widely carried out.
Apart from that, the topic of AI is closely related to "chat GPT", "blended learning", "digital application", "mathematic achievement", "learning media", "Photomath application" and so on. From the visualization above, there are keywords that are far from the AI curve line, namely "blended learning" and "Photomath application" which can be interpreted as new topics in future research because there is still a lack of literature that explores the relationship between these keywords.

Development of Research Research

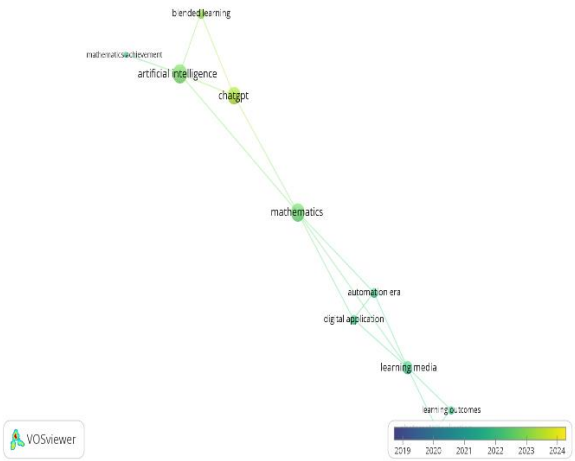

Figure 3. Development of AI Photomath research from all extracted journal articles

The topic that is often studied is the development of AI (artificial intelligence) to imitate the human learning process, especially in the field of education, carried out in 2020 (Chen *et al*., 2020; Gocen & Aydemir, 2020; Voskoglou & Salem, 2020).

In the same year, trials using the Photomath application were also developed and triggered an increase in student independence in learning mathematics (Jupri & Sispiyati, 2020; Medrano Igcasama *et al*., 2020; Riski, 2021; Saundarajan, Osman, Daud, *et al*., 2020). Then the following year, (Gholizadeh *et al*., 2022; Puji Rahayu *et al*., 2022) stated that there is a new problem if the Photomath application causes students to feel dependent on learning mathematics. The problems in this study will continue to be studied in the following years (Bukhatwa, 2024; Helsa *et al*., 2022; Sloan-Lynch *et al*., 2022) and concluded that control is needed to reduce the negative impact of Photomath use.

RESULTS AND DISCUSSION

Research Trends

Analysis of publication trends can provide insight into developments and changes in scientific publications in a particular field or discipline. The research results obtained over the last 4 years, namely from 2019-2024.

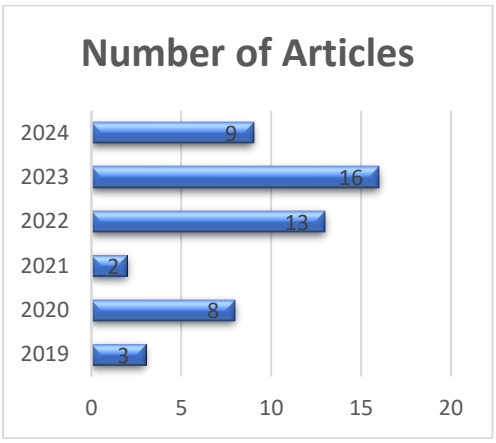

Figure 4. Number of articles published each year

From the results of the researcher's observations, the average publication during that time period was only around 9 articles (see Figure 4). As time goes by, research on the Photomath Artificial Intelligence Application will experience a significant increase in 2023 (n:16). However, it experienced a decline in 2024 with only 9 publications.

After the data was visualized via VOSViewer, researchers extracted the content from each journal article thematically and based on relevance. Extraction was carried out to reveal several findings that are relevant to this research. Through reading the abstract, keywords, and discussion, the researcher summarizes related topics as below (see Table 1).

Table 1. Mapping of relevant journal articles

Author	Findings
(Chen et al., 2020; Gocen & Aydemir, 2020; Lo, 2023; Plevris et al., 2023; Saputra et al., 2023; Shahmohammadi, 2019)	The development of artificial intelligence (AI) technology is starting to develop in the current industrial era and is influencing the world of education, especially in the field of mathematics.
(Dahlan *et al*., 2022; Engelbrecht & Borba, 2023; Ilmiawan *et al*., 2022; Plevris *et al*., 2023; Saundarajan, Osman, Kumar, *et al*., 2020; Zain *et al*., 2023)	Technology facilitates the implementation of flexible learning such as distance learning etc.
(Hwang, 2022; Voskoglou & Salem, 2020; Xu *et al*., 2021)	AI helps educators in administrative functions.
(Remoto, 2024; Sánchez-Ruiz *et al*., 2023; Wardat *et al*., 2023)	ChatGpt is able to improve students' mathematical abilities.
(Capinding, 2023; Fitri *et al*., 2022; Helsa *et al*., 2022; Rabiul Muzammil *et al*., 2023)	*Photomath helps students in learning mathematics.*

(Amparo *et al*., 2022; Derianto *et al*., 2023)	*Photomath helps students increase creativity in learning mathematics.*
(Bukhatwa, 2024; Daguinotan *et al*., 2024; Medrano Igcasama *et al*., 2020)	*Photomath* memiliki potensi untuk meningkatkan hasil belajar siswa
(Aisyah, 2024; Wulandari, 2024)	*Photomath helps students solve math problems through interactive visualization.*
(Bryan Booc *et al*., 2023; Jupri & Sispiyati, 2020; Kurnia Ramadhan *et al*., 2023; Limna *et al*., 2022; Puji Rahayu *et al*., 2022; Sloan-Lynch *et al*., 2022)	AI with Photomath models can have negative impacts, such as academic cheating, students' lack of ability to think, and changing study habits.
(Gholizadeh *et al*., 2022; Meldi *et al*., 2022)	AI-based applications can be used optimally depending on the individual's abilities when operating them.
(Amparo *et al*., 2022; John & Santos, 2022; Limna *et al*., 2022; Tejawiani *et al*., 2023)	Photomath applications can be developed through the school curriculum.
(Winarno *et al*., n.d.)	Recommendations for developing AI in student learning using the TPACK (Technological Pedagogical Content Knowledge) approach
(Dwi Handayani & Solihah, 2022; Stefanova & Georgiev, 2024; Voskoglou & Salem, 2020; Winarno *et al*., n.d.)	To prevent AI's transition from shifting the position of teachers as staff, teachers and students need assistance.
(Trezise *et al*., 2019)	The use of click streams can detect academic cheating by students.

The journal mapping results show that the current era of technological progress facilitates a flexible learning system (Engelbrecht & Borba, 2023). This has a significant impact on the world of education (Gocen & Aydemir, 2020). The existence of AI makes it easier for teaching staff to carry out administration and distance learning activities using AI (Chen *et al*., 2020; Dahlan *et al*., 2022; Ilmiawan *et al*., 2022; Riski, 2021). Apart from that, AI offers a solution for students who have difficulty learning by releasing the ChatGpt website. According to Remoto, (2024) and Wardat *et al*. (2023), ChatGpt is an AI product that is easy for students to use when studying. In some cases, he is even able to answer mathematics-related commands in detail and correctly. However, this answer cannot always be relied on because ChatGpt's consistency is only based on general knowledge.

Based on the results of literature mapping, the author highlights the use of AI-driven mathematics learning applications, namely the Photomath application (Capinding, 2023; Derianto *et al*., 2023; Fitri *et al*., 2022; Helsa *et al*., 2022; Muzammil *et al*., 2023; Saundarajan, *et al*., 2020). Photomath is an application based on processing mathematical data in the form of images and text questions. More than that, Photomath is designed to provide step-by-step explanations for math problems, including word problems, and offers a variety of solution methods. This application provides interesting features and interactive visualizations to help students complete mathematics assignments (Aisyah, 2024; Igcasama *et al*., 2020; Wulandari, 2024). The existence of Photomath is recognized as improving mathematics learning outcomes (Bukhatwa, 2024; Daguinotan et al., 2024; Igcasama et al., 2020).

Muzammil *et al*. (2023) revealed that easy access to Photomaths can increase students' creativity. On the other hand, Photomath, if used optimally, will improve students' mathematics achievements, especially in algebra development (Saundarajan, *et al*., 2020). Therefore, learning mathematics using Photomath can be integrated into the school curriculum (Amparo *et al*., 2022; John & Santos, 2022). Even Winarno *et al*., n.d. explained that integrating AI into the learning curriculum can use the TPACK (Technological Pedagogical Content Knowledge) approach. Apart from that, the integration of AI, especially Photomath, into learning aims to make teachers and students feel familiar or used to using it. Studies by Tejawiani *et al*. (2023) revealed that the Photomath application acts as a tool to improve students' metacognitive abilities in solving integral problems and helps them

develop the skills needed according to the school curriculum. The advantage of Photomath certainly makes the teaching and learning process easier.

The challenge lies in the ease with which AI can have a negative impact on students' responses who are too lazy to think (Bryan Booc et al., 2023; Kurnia Ramadhan et al., 2023; Limna et al., 2022). Jupri & Sispiyati (2020); Puji Rahayu *et al*. (2022); Rabiul Muzammil *et al*. (2023); Sloan-Lynch *et al*. (2022) revealed findings that students experienced dependence and decreased ability to answer practice questions. Students tend to like the instant method of using Photomath so they don't understand symbols or other mathematical terms. In addition, the widespread misuse or academic cheating carried out by students in their study habits has resulted in new challenges that must be addressed immediately (Bryan Booc *et al*., 2023; Kurnia Ramadhan *et al*., 2023; Obina *et al*., 2022). For example, recommendations for using clickstreams can help teachers detect student cheating (Trezise *et al*., 2019).

Thus, the integration of technology into education must be the main focus (Shahmohammadi, 2019). The use of AI requires controls to mitigate the negative risks of AI, especially Photomath applications (Dwi Handayani & Solihah, 2022). According to Voskoglou & Salem (2020); and Winarno *et al*. (n.d.), Assistance in using AI for teachers and students needs to be implemented because the situation of dependence on artificial intelligence can shift the position of teachers as educators. Cabugwason *et al*. (2024) suggest teachers develop strategic strategies and consider varied learning styles so that students' interests and cognitive abilities when learning are active again. Teachers can also collaborate with students' parents to raise students' awareness to use technology wisely.

CONCLUSIONS

Through the previous discussion, it can be concluded that technological advances, especially AI, have had a significant impact on the world of education by providing a more flexible and efficient learning system. AI applications such as ChatGPT and Photomath make it easier for students to learn, especially in completing math assignments. Photomath, in particular, offers step-by-step solutions that enhance students' understanding and creativity. However, there are challenges that arise, such as students' dependence on technology the potential for decreased critical thinking skills, and academic cheating. Therefore, the integration of technology in education must be accompanied by good control, teacher assistance, and collaboration with parents to ensure the wise use of technology and to maintain the important role of teachers in the educational process.

REFERENCES

Aisyah, N. (2024). Studi Literatur : Analisis Kemampuan Berfikir Komputasi Menggunakan Software Matematika Photomath Tingkat SMA. Jurnal Arjuna: Publikasi Ilmu Pendidikan, Bahasa, Dan Matematika, 2(3), 147–155.

Amparo, L. P., Dacup, R. V, Ryan Sales, K. O., Kaye Tocbo, H. D., Rondina, J. Q., Mae Cabiao, A. L., & Olohoy, M. A. (2022). Using Photomath Mobile Application As A Learning Tool In Teaching Algebra During Distant Learning. Sci. Int. (Lahore), 34(3), 331–334. https://doi.org/10.1007/s10763011-9279-y

Bryan Booc, N., Sobremisana, K., Ybañez, A., Tolosa, R., Ladroma, S. M., & Caparoso, K. M. (2023). Artificial Intelligence-Powered Calculator Application Usage in Mathematics Summative Assessments. IRE Journals, 6(10), 446–474.

Bukhatwa, B. (2024). Students' attitudes towards Photomath application in solving calculus problems using mobile camera. International Journal of Scientific Development and Research (IJSDR), 9(2), 251–259. http://www.ijsdr.org

Cabugwason, M. R., Laoreno, B. G., Galoy, R. M. P., Valila, A. J., & Nobis, M. L. (2024). Math Apps in Math Education: Experiences and Challenges of Pre-Services Teachers. IGNATIAN: International Journal for Multidisciplinary Research, 2(5), 1909–1922.

Capinding, A. T. (2023). Revolutionizing Pre-Calculus Education: Photomath's Ai-Powered Mathematics Tutorship. Problems of Education in the 21st Century, 81(6), 758–775. https://doi.org/10.33225/pec/23.81.758

Chen, L., Chen, P., & Lin, Z. (2020). Artificial Intelligence in Education: A Review. IEEE Access, 8, 75264–75278. https://doi.org/10.1109/ACCESS.2020.2988510

Daguinotan, J. H. N., Gamba, J. J. M., Gonzales, M. S. S., & Dajao, H. A. M. (2024). Utilization of Photomath Among Grade 7 Junior High School Students. Journal of Learning and Educational Policy, 42, 31–39. https://doi.org/10.55529/jlep.42.31.39

Dahlan, T., Darhim, D., & Juandi, D. (2022). How Digital Applications As Mathematics Learning Media in the Automation Era. Journal of Positive Psychology and Wellbeing, Vol.6(2), 199–211. http://journalppw.com

Derianto, Putra, M., & Sari, I. K. (2023). Peningkatkan Hasil Belajar Siswa Pada Materi Fungsi Dengan Menggunakan Aplikasi Photomath Di Kelas X Sma Negeri 1 Montasik Aceh Besar. Jurnal Ilmiah Mahasiswa, 4(1).

Dwi Handayani, S., & Solihah, A. (2022). Kapas : Kumpulan Artikel Pengabdian Masyarakat Pemanfaatan Aplikasi Photomath dan Aplikasi YHomework pada Pembelajaran Matematika. Kapas : Kumpulan Artikel Pengabdian Masyarakat, 1(1), 1–7. https://doi.org/http://dx.doi.org/10.30998/kapas.v1i1.1208

Engelbrecht, J., & Borba, M. C. (2023). Recent developments in using digital technology in mathematics education. ZDM - Mathematics Education. https://doi.org/10.1007/s11858-023-01530-2

Fitri, M., Sibuea, L., Sembiring, M. A., Lubis, I. A., Agus, T. A., Studi, P., Informasi, S., Tinggi, S., Dan, I., Royal, K., Almeina, I., Tama, R., Agus, A., Studi, P., & Informasi, S. (2022). Pemanfaatan Aplikasi Photomath Sebagai Media Belajar Matematika. In Jurnal Pemberdayaan Sosial dan Teknologi Masyarakat (Vol. 2, Issue 1). http://jurnal.goretanpena.com/index.php/JPSTM

Gholizadeh, M., Akhlaghpour, S., Isaias, P., & Namvar, M. (2022). Emergent affordances and potential challenges of mobile learning apps: insights from online reviews. Information Technology and People, 35(7), 2500–2517. https://doi.org/10.1108/ITP-05-2021-0412

Gocen, A., & Aydemir, F. (2020). Artificial Intelligence in Education and Schools. Research on Education and Media, 12(1), 13–21. https://doi.org/10.2478/rem-2020-0003

Helsa, Ariani, Andika, Zainil, Masniladevi, & Ranuharja. (2022). Ketergantungan pada teknologi: intellectual virtual photo math solves equations with mobile camera Journal on Mathematics Education Research. Journal on Mathematics Education Research, 3(2), 91–98.

Hwang, S. (2022). Examining the Effects of Artificial Intelligence on Elementary Students' Mathematics Achievement: A Meta-Analysis. Sustainability (Switzerland), 14(20). https://doi.org/10.3390/su142013185

Ilmiawan, K., Suryaningtyas, W., & Efendi, J. F. (2022). Meta Analisis: Penggunaan Dan Pemanfaatan Aplikasi Mobile Matematika Dalam Pembelajaran Matematika Sebelum Dan Selama Masa Pandemi Covid-19. Pedagogy Jurnal Pendidikan Matematika, 7(2), 147–166. https://doi.org/https://doi.org/10.30605/pedagogy.v7i2.2050

John, E., & Santos, V. L. (2022). Comparative Analysis of Mobile Applications for its Integration in College Mathematics Subjects. EDUCATION : Journal Of Education, 6(4).

Jupri, A., & Sispiyati, R. (2020). Students' Algebraic Proficiency from the Perspective of Symbol Sense. Indonesian Journal of Science & Technology, 5(1), 86–94. https://doi.org/10.17509/ijost.v5i1/23102

Kurnia Ramadhan, F., Irfan Faris, M., Wahyudi, I., & Kamayani Sulaeman, M. (2023). Pemanfaatan Chatgpt Dalam Dunia Pendidikan. JURNAL ILMIAH FLASH, 9(1), 25–30. https://doi.org/https://doi.org/10.32511/flash.v9i1.1069

Limna, P., Jakwatanatham, S., Siripipattanakul, S., Kaewpuang, P., & Sriboonruang, P. (2022). A Review of Artificial Intelligence (AI) in Education during the Digital Era. https://ssrn.com/abstract=4160798

Lo, C. K. (2023). What Is the Impact of ChatGPT on Education? A Rapid Review of the Literature. In Education Sciences (Vol. 13, Issue 4). MDPI. https://doi.org/10.3390/educsci13040410

Medrano Igcasama, R., Ramirez, D. T., Salanap, N. P., Igcasama, R. M., Ramirez, D. T., & Salanap, N. P. (2020). Evaluation of Photo Math in Teaching Elementary Algebra. Journal of Educational Research and Evaluation, 4(4), 408–413. https://doi.org/10.23887/jere.v4i4.29749

Meldi, N. F., Yani T., A., & Suratman, D. (2022). Penyelesaian Persamaan Bentuk Kuadrat Berbantuan Aplikasi Photomath Berdasarkan Sistem Bilangan Real. Variable, 5(2), 83. https://doi.org/10.26737/var.v5i2.3224

Obina, J. E., Gabe, J. B., Angcon, S. M. D., Diaz, B. T. R., Largo, V. J. Y., Chiva, M. C., & Bolaños, J. G. (2022). Math Apps Utilization: Its Perceived Effects To The Academic Performance Of Mathematics Major Students. European Journal of Education Studies, 9(9). https://doi.org/10.46827/ejes.v9i9.4459

Plevris, V., Papazafeiropoulos, G., & Jiménez Rios, A. (2023). Chatbots Put to the Test in Math and Logic Problems: A Comparison and Assessment of ChatGPT-3.5, ChatGPT-4, and Google Bard. AI (Switzerland), 4(4), 949–969. https://doi.org/10.3390/ai4040048

Puji Rahayu, N., Negeri, S., & Grobogan, K. (2022). Meminimalkan Ketergantungan Peserta Didik pada Aplikasi Photomath dengan Merubah Soal Matematika Menjadi Bentuk Teks. Action Research Journal, 1(3), 2808–5159.

Rabiul Muzammil, A., Ari Asfar, D., Za, M., Shidqi, I., Adang Edithya Astama, R., Dermawan Muhammad, R., & Adinugraha Mahadi, C. (2023). Persepsi Mahasiswa S-1 terhadap Pemanfaatan Photomath dalam Pemecahan Persoalan Matematika. Jurnal Kependidikan, 12(4). https://doi.org/https://doi.org/10.58230/27454312.285

Remoto, J. P. (2024). ChatGPT and other AIs: Personal relief and limitations among mathematics-oriented learners. Environment and Social Psychology, 9(1). https://doi.org/10.54517/esp.v9i1.1911

Riski, D. (2021). An Analysis of Conceptual Understanding and Student's Learning Self-Reliance in the New Normal Era Assisted by Photomath on SLETV Material. https://doi.org/https://doi.org/10.2991/assehr.k.210508.058

Sánchez-Ruiz, L. M., Moll-López, S., Nuñez-Pérez, A., Moraño-Fernández, J. A., & Vega-Fleitas, E. (2023). ChatGPT Challenges Blended Learning Methodologies in Engineering Education: A Case Study in Mathematics. Applied Sciences (Switzerland), 13(10). https://doi.org/10.3390/app13106039

Saputra, H., Utami, L. F., & Purwanti, R. D. (2023). Era Baru Pembelajaran Matematika: Menyongsong Society 5.0. Indiktika : Jurnal Inovasi Pendidikan Matematika, 5(2), 146–157. https://doi.org/10.31851/indiktika.v5i2.11155

Saundarajan, K., Osman, S., Kumar, J. A., Daud, M. F., Abu, M. S., & Pairan, M. R. (2020). Learning Algebra using Augmented Reality: A Preliminary Investigation on the Application of Photomath for Lower Secondary Education. International Journal of Emerging Technologies in Learning (IJET), 15(16), 123. https://doi.org/10.3991/ijet.v15i16.10540

Shahmohammadi, S. B. (2019). Opportunities and Challenges in Using Dynamic Software in Mathematics Education. International Journal for Infonomics, 12(1), 1834–1840. https://doi.org/10.20533/iji.1742.4712.2019.0187

Sloan-Lynch, J., Gay, N., & Watkins, R. (2022). Too Fast for Their Own Good: Analyzing a Decade of Student Exercise Responses to Explore the Impact of Math Solving Photo. ACM International Conference Proceeding Series, 67–76. https://doi.org/10.1145/3506860.3506868

Stefanova, T., & Georgiev, S. (2024). Possibilities For Using AI in Mathematics Education. Proceedings of the Fifty-Third Spring Conference of the Union of Bulgarian Mathematicians Borovets, 117–125.

Tejawiani, I., Sucahyo, N., Usanto, U., & Sopian, A. (2023). Peran Artificial Intelligence Terhadap Peningkatan Kreativitas Siswa Dengan Menerapkan Proyek Penguatan Profil Pelajar Pancasila. JMM (Jurnal Masyarakat Mandiri), 7(4), 3578. https://doi.org/10.31764/jmm.v7i4.16143

Trezise, K., Ryan, T., de Barba, P., & Kennedy, G. (2019). Detecting contract cheating using learning analytics. Journal of Learning Analytics, 6(3), 90–104. https://doi.org/10.18608/jla.2019.63.11

Voskoglou, M. G., & Salem, A. B. M. (2020). Benefits and limitations of the artificial with respect to the traditional learning of mathematics. Mathematics, 8(4). https://doi.org/10.3390/math8040611

Wardat, Y., Tashtoush, M. A., Ali, R., & Jarrah, A. M. (2023). ChatGPT: A revolutionary tool for teaching and learning mathematics. Eurasia Journal of Mathematics, Science and Technology Education, 19(7). https://doi.org/10.29333/ejmste/13272

Winarno, Auna, H. S., & Sugiarni. (n.d.). Pendekatan Pembelajaran TPACK Menggunakan Tools Berbasis Artificial Intelligence (AI): Manfaat dan Tantangan.

Wulandari, T. (2024). Pemanfaatan Aplikasi Photomath pada Pembelajaran Matematika: Systematic Literature Review. Journal of Multidisciplinary Inquiry in Science Technology and Educational Research, 1(3), 332–339. https://doi.org/10.32672/mister.v1i3.1549

Xu, Y., Liu, X., Cao, X., Huang, C., Liu, E., Qian, S., Liu, X., Wu, Y., Dong, F., Qiu, C. W., Qiu, J., Hua, K., Su, W., Wu, J., Xu, H., Han, Y., Fu, C., Yin, Z., Liu, M., … Zhang, J. (2021). Artificial intelligence: A powerful paradigm for scientific research. In Innovation (Vol. 2, Issue 4). Cell Press. https://doi.org/10.1016/j.xinn.2021.100179

Zain, I. N. M., Setambah, M. A. B., Othman, M. S., & Hanapi, M. H. M. (2023). Use of Photomath Applications in Helping Improving Students' Mathematical (Algebra) Achievement. European Journal of Education and Pedagogy, 4(2), 85–87. https://doi.org/10.24018/ejedu.2023.4.2.601