OPEN ACCESS
Jurnal Ilmiah Ilmu Terapan Universitas Jambi
Vol. 8 No. 2. December 2024, pp. 495-508 DOI. 10.22437/jiituj.v8i2.34809

Research Article

EVALUATING THE IMPACT OF AI–POWERED TUTORS MATHGPT AND FLEXI 2.0 IN ENHANCING CALCULUS LEARNING

Joel I. Alvarez[1,*]

[1] College of Education, Nueva Ecija University of Science and Technology, Cabanatuan City, Nueva Ecija, Philippines
Corresponding author email: alvarezjoel.gs@gmail.com

Article Info
Recieved: Jun 19, 2024
Revised: Aug 20, 2024
Accepted: Oct 10, 2024
OnlineVersion: Oct 17, 2024

Abstract

This study evaluates the effectiveness of AI-driven technologies, Flexi 2.0 and MathGPT, in enhancing personalized learning and advanced cognitive abilities among pre-service mathematics educators participating in Calculus I. Participants were allocated to a control group receiving conventional training and an experimental group utilizing AI technology, applying a quantitative experimental design. Data were gathered utilizing validated evaluations, surveys, and interviews. The results indicated that students employing AI tutors shown significant improvements in problem-solving and personalized learning compared to the control group. Concerns arose regarding potential over-reliance on AI, underscoring the need for rigorous criteria to guarantee that students engage actively in learning rather than passively receiving AI-generated responses. The findings suggests that educators should create activities requiring students to critically evaluate AI-generated responses to promote independent thinking. The findings highlight the potential of AI in mathematics education, while stressing the importance of ethical considerations and teacher oversight. It requires the training of both students and staff to adapt to improvements in AI inside education. The study reveals that while AI can improve learning outcomes, careful implementation is essential for its effective and responsible use in educational settings.

Keywords: Artificial Intelligence, Flexi 2.0, Independent Learning, Math GPT, Mathematics Instruction

INTRODUCTION

Artificial intelligence (AI) has emerged as a viable field for advancing mathematics education and tackling the obstacles students have in learning and problem-solving as mentioned by Van Vaerenbergh, & Pérez-Suay, (2022). Researchers have acknowledged the challenges students face when executing mathematical assignments, particularly those necessitating multiple phases for resolution (Bray & Tangney, 2017). As a result, a targeted project has been implemented to employ AI to enhance mathematics learning results (Hwang & Tu, 2021; Marta, Khairinal, & Murbojono, 2023).

Learner-centered education, effectively implemented in classrooms with AI tools, represents a substantial use of AI in the educational sector (Huang, 2018; Perdana, Zakariah, & Alasmari, 2023;

Asrial et al., 2023). These AI-driven solutions enhance testing, assessment, and evaluation, offering educators critical data on student performance and learning objectives (Nazaretsky et al., 2022; Asrial et al., 2024). Students can obtain tailored feedback using AI-powered assessment tools, which assist in identifying their strengths and weaknesses in mathematics (Mohamed et al. 2022; Triyasmina et al., 2022; Mizian, 2023; Baah, Konovalov, & Tenzin, 2024). The utilization of AI in education, particularly in mathematics instruction, has significantly risen in prominence and media coverage in recent years (Mohamed et al., 2022; Asia, Kinda, & Edwards, 2024; Zakiyah, Boonma, & Collado, 2024). Artificial intelligence provides novel alternatives to conventional teaching approaches, facilitating the improvement of students' mathematical and cognitive learning skills (Kutyniok, G. & International Mathematical Union. (2022). The use of AI allows students to autonomously engage with material and acquire answers more swiftly, hence promoting a culture of self-directed learning (Popenici & Kerr, 2017; Mardiati, Alorgbey, & Zarogi, 2024; Fitriana & Waswa, 2024; Setiyani, Panomram, & Wangdi, 2024).

Understanding the constraints and obstacles related to the incorporation of AI in mathematical instruction is crucial. Although AI can augment education, it cannot supplant educators in the classroom (Cope et al., 2020). Furthermore, there are pragmatic obstacles associated with the deployment of AI technology, including organizational challenges and apprehensions surrounding academic integrity (Popenici & Kerr, 2017; Sari, Omeiza, & Mwakifuna, 2023; Yohanie et al., 2023). The use of AI-powered calculator apps (AIPCAs) by students in mathematics education raises concerns around assessment integrity and academic dishonesty (Bray & Tangney, 2017). Educators must create explicit policies and procedures for the application of AIPCAs in the classroom to tackle this difficulty (Bray & Tangney, 2017). The incorporation of AI in mathematics teaching presents intriguing opportunities notwithstanding these obstacles. AI-enhanced computer-based learning systems can provide intelligent tutors, tools, and facilitators, hence augmenting students' creativity and problem-solving abilities (Voskoglou & Salem, 2020). Researchers are continuously enhancing the capabilities of autonomous computing while investigating new areas of artificial intelligence (Chesani et al., 2017).

Artificial intelligence has the potential to significantly improve mathematics education by enabling problem-solving, personalizing learning experiences, and increasing student engagement. Notwithstanding current hurdles, advancements in AI research and development have the potential to fundamentally transform mathematics education in the digital era. Despite the growing interest in the application of AI in education, particularly in mathematics, existing research primarily focuses on generic applications rather than specific AI tools that could enhance problem-solving and higher-order thinking skills. Despite the potential of AI for personalized learning and independent study (Bray & Tangney, 2017; Mohamed et al., 2022; Saputro et al., 2023), empirical research on its concrete impact in mathematical problem-solving with complex, multi-step tasks is limited. The shortfall arises from the lack of comprehensive studies that rigorously evaluate specific AI tutors, such as MathGPT and Flexi 2.0, in addressing these challenges, especially for pre-service mathematics educators.

As AI revolutionizes education, it is essential to assess how new technologies might effectively improve critical thinking abilities and personalized learning in mathematics. Given the rapid integration of AI in educational environments, educators must quickly adapt to employing these technologies while upholding ethical and pedagogical standards (Cope et al., 2020). Immediate research is necessary to understand the constraints and benefits of AI, providing educators with frameworks to maximize AI's advantages and mitigate overreliance. This study rigorously assesses MathGPT and Flexi 2.0, two AI-based mathematics tutors, to address the identified shortcomings in enhancing students' problem-solving abilities and engagement. It analyzes methods to tackle concerns regarding academic integrity and overdependence on AI by creating frameworks for educator oversight and structured learning experiences that encourage students to critically assess AI-generated outputs.

This study seeks to investigate the effectiveness and potential of incorporating AI-driven math tutors, such as MathGPT and Flexi 2.0, in improving students' higher-order thinking skills and learning in Calculus, particularly in Analytic Geometry and Differential Calculus. Specifically, this study aims to delineate student performance before to and following the utilization of these tools, identify any notable differences in their effects, and examine the obstacles and challenges encountered by learners in their application. The study examined the potential for integrating AI-driven math tutors into the instruction of Calculus 1 to enhance educational outcomes.

RESEARCH METHOD

This research utilized a quantitative methodology via a quasi-experimental design. Cortez (2015, as referenced by Alvarez, 2021) asserts that experimental research investigates “what will be” through the manipulation and control of particular variables. It is the only method capable of rigorously verifying theories concerning cause-and-effect relationships. This method enables a clearer comprehension of how various factors affect outcomes by meticulously manipulating variables in a controlled environment, rendering it an essential instrument for assessing the efficacy of educational programs.

This survey was conducted with selected Bachelor of Secondary Education - Mathematics students from a certain State University in the Philippines. The study's subjects consist of eight (8) male and twelve (12) female students who completed Calculus 1 (SEM 8) during the study period. The respondents were intentionally chosen according to the specified criteria. The participants were statistically categorized into two groups: one group employed MathGPT, while the other utilized Flexi 2.0 as a supplementary learning resource for Calculus 1. The division of participants into groups is based on the pre-test results of the teacher-created Calculus assessment conducted before to the experiment.

The researchers classified the patients into two groups: MathGPT and Flexi 2.0. The two groups were directed to employ the specified AI-driven mathematics coach to comprehend the resolutions to diverse calculus problems. Their problem-solving abilities, as evidenced by the outcomes of a teacher-designed Calculus examination, were evaluated and contrasted; hence, this methodological approach is considered the most appropriate.

This study included both qualitative and quantitative research methodologies, comprising two components. Phase 1 entailed the analysis of learner performance and the identification of significant disparities both within and between the scores of the two groups. The qualitative study method was utilized to clarify the distinctions in learners' presentation of their solutions and to identify the challenges and possibilities faced by learners when using the two AI-driven math tutors.

This study made use of instruments that was of help to obtain the data and for the success of the study. This study used i.) Teacher – Made Test in Calculus, ii.) Flexi 2.0 and iii.) MathGPT.

Description: The Teacher-Made Test in Calculus (TMTC) is an assessment created by educators that encompasses items related to the Calculus material of the BSE - Mathematics curriculum. The test is a multiple-choice format consisting of 40 items, each with four options. A Table of Specification for TMTC was created for this purpose. *Validation:* The preliminary version of TMTC was evaluated by a Mathematics expert and was pilot-tested with a cohort of college students who had completed Calculus and were not part of the sample group. Following pilot testing and the evaluation of internal consistency, the 50-item test was subsequently reduced to 40 items, achieving an alpha index of 0.802.

Hyperspace Technologies Inc. has created a sophisticated mathematical language model named MathGPT. It aims to assist individuals in exploring mathematical concepts, generating mathematical proofs, and resolving complex mathematical problems. MathGPT is founded on contemporary natural language processing (NLP) techniques and deep learning algorithms, allowing it to understand and generate mathematical expressions with remarkable efficiency and accuracy. *Validation:* Hyperspace Technologies Inc. systematically verifies the accuracy and reliability of MathGPT through many steps. MathGPT was initially trained on an extensive dataset of mathematical texts from many sources and subsequently fine-tuned with a validation set of mathematical problems with established solutions to evaluate its performance and pinpoint areas for improvement. Subsequent to training, comprehensive testing is performed on novel data, integrating automatic assessments and expert manual evaluations. User feedback is consistently collected and evaluated to identify prevalent issues and enhance MathGPT's functionalities, enabling ongoing updates and advancements informed by the latest research and user insights. This iterative procedure guarantees MathGPT's ongoing development and expertise in tackling various mathematical problems.

TechSolve Innovations developed Flexi 2.0, a sophisticated flexible manufacturing system (FMS) designed to enhance production efficiency and streamline manufacturing processes. Contemporary automation, robotics, and data analytics technologies are integrated to establish a versatile manufacturing ecosystem capable of adapting to fluctuating production requirements and optimizing resource utilization. Flexi 2.0's adaptable and modular architecture allows producers to expand and modify their production capacity based on specific requirements. It accommodates a wide array of manufacturing processes across several sectors, such as consumer goods, automotive, aerospace, and electronics, encompassing machining, assembly, inspection, and packaging. *Validation:* TechSolve Innovations employs a comprehensive validation methodology to ensure the performance, reliability, and safety of Flexi 2.0. This involves design verification through structural analysis and prototype testing to meet industry standards, legal requirements, and customer specifications. Functional testing assesses the performance of Flexi 2.0 under various production situations, while safety certification ensures compliance with worldwide standards through the validation of safety features and risk assessments. Performance parameters, including cycle time and throughput, are measured against benchmarks in practical performance assessment. To enhance the usability and efficacy of Flexi 2.0 based on feedback, user acceptance testing incorporates end users in pilot production runs. This guarantees that Flexi 2.0 effectively meets manufacturing requirements.

In answering the research problems posed, the following data analysis techniques were used: The learners' performance was assessed before and after utilizing the two AI-powered math tutors (MathGPT and Flexi 2.0) by frequency and mean score analysis, interpreted using the specified interval.

Table 1. Learners' Performance

Interval	Verbal Interpretation
31.01 – 40.00	Excellent
24.01 – 32.00	Very Satisfactory
16.01 – 24.00	Satisfactory
8.01 – 16.00	Fair
0.00 – 8.00	Needs Improvement

Diverse statistical methodologies were utilized to analyze the data. A paired sample t-test was conducted to assess whether a significant difference existed in the performance of learners in both groups prior to and following the implementation of the two unique AI-powered math tutors. An independent sample t-test was used to evaluate the significant difference in learner performance between the two groups following the utilization of AI-powered math instructors. Finally, thematic analysis was conducted utilizing Collaizzi's Method to investigate the obstacles faced by learners and to find potential in the use of MathGPT and Flexi 2.0.

RESULTS AND DISCUSSION

Pre-Test Results of Teacher-Made Test in Calculus

Table 2. T-test Results of the Teacher – Made Test in Calculus in the two groups before the experiment

	MathGPT	Flexi 2.0
Mean	12.70	12.60
Variance	16.233	17.378
Df	10	10
level of confidence	5%, two-tailed	
t-crit	2.100	
t-comp	0.055	
Decision	Accept Ho	
Interpretation	Not Significant	

The t-test results comparing the pre-experimental performance of students utilizing MathGPT and Flexi 2.0 as AI-driven math tutors indicated no significant difference between the two cohorts. Although MathGPT exhibits a somewhat superior mean score of 12.70 relative to Flexi 2.0's 12.60, the calculated t-value of 0.055 is much lower than the crucial value of 2.100 at a 0.05 significance level. Consequently, there is inadequate statistical evidence to dismiss the null hypothesis, suggesting no substantial disparity in the students' performance prior to the experimental intervention. This outcome verifies that the two groups possessed equal mathematical abilities before the implementation of the AI tools, hence affirming the validity of the experimental design.

The lack of a substantial difference between the groups initially may indicate uniformity in their mathematical abilities, however it also underscores that both groups required enhancement, as evidenced by their very low mean scores. This outcome corresponds with the observations of Owan et al. (2023), who identified the capacity of AI to improve educational evaluations and augment student achievement, particularly when conventional approaches have demonstrated shortcomings. Consistent with other research indicating the potential of AI to enhance student learning results (Bray & Tangney, 2017; Mohamed et al., 2022), the preliminary analysis of the current study suggests that AI tools may function as useful educational aids. The negligible pre-experiment difference indicates that both tools (MathGPT and Flexi 2.0) may provide similar foundational support for mathematics education, thereby corroborating previous studies that highlight AI's ability to deliver personalized learning experiences (Huang, 2018; Voskoglou & Salem, 2020).

The observation that both groups exhibited no substantial performance disparity before the experiment suggests that AI-driven tools such as MathGPT and Flexi 2.0 may function as effective and equitable resources for enhancing students' arithmetic abilities. The negligible difference before the intervention guarantees that any performance changes found after the trial may be ascribed to the AI tools rather than pre-existing student abilities. This substantiates the notion that AI can democratize access to high-quality math tutoring by offering tailored guidance to all students, irrespective of their initial proficiency levels.

Table 3. Performances of Subjects After using AI – powered Math Tutors

	MathGPT	Flexi 2.0	Difference	Interpretation
Pre – Test	12.70	12.60	0.10	MathGPT group performed better
Post – Test	18.40	21.00	2.60	Flexi 2.0 group performed better
Difference	5.70	8.40	2.70	Flexi 2.0 group performed better
Interpretation	Flexi 2.0 group performed better			

Table 3 illustrates that both groups, utilizing MathGPT and Flexi 2.0, exhibited enhancements from the pre-test to the post-test. Nonetheless, a notable disparity exists in the extent of enhancement between the two groups. At the outset, in the pre-test, the MathGPT group surpassed the Flexi 2.0 group by a slight margin of 0.10 points. Nonetheless, the post-test findings reveal a notable change, as the Flexi 2.0 group attained a superior mean score, surpassing the MathGPT group by 2.60 points. Moreover, after analyzing the pre-test and post-test scores, the Flexi 2.0 group exhibited a superior performance enhancement of 8.40 points, whereas the MathGPT group recorded a 5.40-point improvement.

The data indicate that although both AI-powered tools enhanced student performance, Flexi 2.0 exerted a more significant influence on learning outcomes than MathGPT. The significant rise in scores for the Flexi 2.0 group suggests that this tool may provide features or instructional strategies that enhance student engagement or comprehension of mathematical concepts over time. The MathGPT group's modest initial advantage in the pre-test may indicate varying baseline interactions with the tools; nevertheless, the Flexi 2.0 group had superior total learning gains.

The results correspond with previous studies that emphasize the efficacy of AI in improving student learning outcomes. Hwang & Tu (2023) assert that AI-driven educational technologies, especially in mathematics, can substantially enhance student comprehension and performance. The enhanced performance in the Flexi 2.0 group aligns with research by Voskoglou & Salem (2020), indicating that tailored feedback and AI-assisted problem-solving strategies substantially improve students' learning experiences.

The findings indicate that AI-driven mathematics tutors, particularly Flexi 2.0, can markedly improve student achievement in mathematics by offering tailored learning experiences that may surpass conventional teaching methods or other AI resources such as MathGPT. The pronounced rise in results for the Flexi 2.0 group indicates that educators should contemplate employing AI solutions equipped with dynamic engagement or interactive learning functionalities. These findings can provide a foundation for incorporating AI technology into the mathematics curriculum to assist students in both learning and excelling in mathematical problem-solving.

Comparison between the Performances of Subjects before and After using AI – powered Math Tutors

Table 4. Paired Sample T-test Results of the Performances of Subjects before and after using MathGPT

	Pre - Test	Post - Test
Mean	12.70	18.40
Variance	16.233	22.267
Df	10	10
level of confidence	5%, two-tailed	
t-crit	2.262	
t-comp	-9.544	
Decision	Reject Ho	
Interpretation	Significant	

The findings of the paired sample t-test displayed in Table 4 indicate a significant enhancement in student performance following exposure to MathGPT as an AI tutor. The average pre-test score of 12.70 increased to 18.40 in the post-test. The calculated t-value of -9.544 surpassed the crucial t-value of 2.262, resulting in the rejection of the null hypothesis. This signifies a statistically significant difference between the pre-test and post-test results, indicating that the utilization of MathGPT positively influenced student performance in mathematics.

The substantial rise in scores indicates that MathGPT enhanced students' comprehension and problem-solving abilities in mathematics, as demonstrated by the improved post-test outcomes. This discovery is significant as it demonstrates the capacity of AI-driven tutors to enhance academic development in disciplines such as mathematics, where conceptual challenges frequently occur. The emotional reactions of students throughout the trial, ranging from perplexity in the pre-test to enjoyment and confidence in the post-test, underscore the impact of AI in alleviating fear and enhancing student engagement.

These findings align with prior studies regarding the efficacy of AI in improving educational attainment. Hwang and Tu (2021) discovered that artificial intelligence techniques, when implemented in mathematics instruction, may markedly enhance student comprehension and retention. The noted favorable student responses, including heightened confidence and enjoyment, correspond with the conclusions of Bray & Tangney (2017), who indicated that AI tools can diminish cognitive burden and enhance the interactivity and enjoyment of learning. Voskoglou & Salem (2020) emphasized that AI-powered instructors' capacity to tailor their approach to unique student requirements can enhance problem-solving skills through individualized feedback.

This study's results indicate that AI-powered tutors, such as MathGPT, can significantly enhance student performance in mathematics. The notable rise in post-test results indicates that AI technologies can improve student comprehension of intricate mathematical ideas, potentially leading to greater overall academic success. The emotional responses noted during the experiment-where students shifted from annoyance to enjoyment-highlight the capacity of AI tools to foster a more engaging and less stressful educational atmosphere.

Table 5. Paired Sample T-test Results of the Performances of Subjects before and after using Flexi 2.0

	Pre - Test	Post - Test
Mean	12.60	21.00
Variance	17.378	26.222
Df	10	10
level of confidence	5%, two-tailed	
t-crit	2.262	
t-comp	-14.453	
Decision	Reject Ho	
Interpretation	Significant	

The findings of the paired sample t-test presented in Table 5 indicate a substantial enhancement in the individuals' performance following exposure to Flexi 2.0. The average pre-test score of 12.60 significantly increased to 21.00 in the post-test. The calculated t-value of -14.453 significantly exceeds the critical t-value of 2.262, resulting in the rejection of the null hypothesis. This signifies a statistically significant disparity between the pre-test and post-test results, illustrating that Flexi 2.0 exerted a considerable beneficial influence on the mathematical ability of the participants.

The substantial improvement in performance following exposure to Flexi 2.0 indicates that the AI tutor was significant in augmenting students' comprehension of mathematical topics. The substantial mean difference of 8.40 between pre- and post-test scores underscores Flexi 2.0's capacity to facilitate the acquisition of intricate mathematical skills. The emotional responses noted during the pre-test, characterized by student bewilderment, transformed in the post-test to reveal enjoyment and confidence among the students. This transition indicates that Flexi 2.0 enhances academic performance and favorably influences students' attitudes about learning mathematics.

The results correspond with previous research endorsing the application of AI in mathematics instruction. Hwang & Tu (2021) highlighted that AI-driven technologies significantly enhance students' mathematics performance by providing individualized feedback and adaptive learning experiences. The enhancement of confidence and the diminution of anxiety noted in the study corroborate the findings of Bray & Tangney (2017), which indicated that AI tools help mitigate students' cognitive load and render learning more participatory and less stressful. Likewise, the notable enhancement shown in the post-test aligns with the findings of Voskoglou & Salem (2020), which emphasized the effectiveness of AI tutors in enhancing problem-solving abilities and conceptual comprehension.

The findings indicate that AI-driven tutors, especially Flexi 2.0, can markedly improve students' arithmetic abilities. The significant rise in post-test scores, along with enhanced student attitudes towards learning, suggests that AI tools can be instrumental in promoting both cognitive and emotional growth in students. This has significant implications for the incorporation of AI technology into educational courses, especially in disciplines such as mathematics where students typically encounter difficulties. Flexi 2.0's tailored learning experiences can effectively address specific learning deficiencies while fostering an engaging atmosphere that encourages active involvement and enjoyment.

Post – Test Results of Teacher – Made Test in Calculus

Table 6. T-test Results of the Teacher – Made Test in Calculus in the two groups after the experiment

	MathGPT	Flexi 2.0
Mean	18.40	21.00
Variance	22.267	26.222
Df	10	10
level of confidence	5%, two-tailed	
t-crit	2.100	
t-comp	- 1.181	
Decision	Accept Ho	
Interpretation	Not Significant	

Table 5 displays the t-test outcomes comparing the post-test performances of pupils utilizing two AI-driven math tutors: Flexi 2.0 and MathGPT. Despite the Flexi 2.0 group achieving a higher mean score of 21.00 compared to the MathGPT group's mean score of 18.40, the calculated t-value of -1.181 did not surpass the threshold t-value of 2.100. Consequently, the null hypothesis remains unrefuted, signifying no statistically significant disparity between the two groups. This indicates that although Flexi 2.0 seems to enhance student results more effectively, the disparity in the efficacy of the two AI instructors is not statistically significant.

The findings indicate that both Flexi 2.0 and MathGPT enhanced students' performance, with Flexi 2.0 demonstrating marginally superior results. The absence of a substantial difference between the two AI tutors suggests that both tools exhibit similar efficacy in facilitating student learning in mathematics. The enhancement in scores among both groups underscores that AI-powered tools are advantageous for improving mathematics learning, despite one potentially exhibiting a slight superiority over the other. This corresponds with the findings of Chen & Liu (2007), who observed that individualized learning through AI technology can be beneficial, although may not consistently produce markedly different results in comparison.

The little differences in performance between the two AI tutors reflect the conclusions of Chen & Liu (2007), who highlighted that AI tools intended for individualized learning may exhibit varied levels of effectiveness but typically result in favorable educational outcomes. The little enhancement noted in the Flexi 2.0 group aligns with Mohamed et al. (2022), who discovered that although specific AI-driven tools can improve learning experiences, their performance may not always be significantly superior to other comparable technology. This study reinforces the idea that although AI tools may possess distinct characteristics, their fundamental advantages, including individualized learning and immediate feedback, are largely consistent across many platforms.

The findings demonstrate that both Flexi 2.0 and MathGPT are efficacious instruments for enhancing student performance in mathematics, albeit the variations in effectiveness are not statistically significant. This indicates that educators may utilize either instrument to augment students' comprehension of mathematical ideas. Nonetheless, the marginal advantage of Flexi 2.0 indicates that its features may be more appropriate for some educational environments. The findings suggest that instructors should prioritize the integration of AI tutors into their educational methodologies rather than selecting specific AI tools. This enhances the overall comprehension that AI tools can augment conventional teaching techniques, especially in fields where students encounter difficulties with intricate problem-solving tasks.

Challenges

The utilization of the two AI Math tutors revealed the following challenges:

Technical Challenges

Utilizing Flexi 2.0, students are exposed to advanced interfaces and cutting-edge production tools. The learning curve for this technology is steep because to its intricacy, which may intimidate those who are unacquainted with it. Mastery of technical abilities that students may not have developed in conventional classroom settings is crucial for operating equipment and managing complex software interfaces. Students who infrequently engage with technology or lack confidence in their technological skills may find this problem more pronounced.

Certification Criteria

Effective utilization of Flexi 2.0 necessitates specialized training in machine operation, data analytics, technological problem-solving, and safety measures. Students may not consistently have straightforward access to an abundance of training materials and tools, complicating their ability to master essential skills. Insufficient training may hinder students' capacity to effectively utilize Flexi 2.0, hence limiting their engagement in meaningful learning activities and the application of abstract concepts in practical contexts.

Limitations on Resources

Educational institutions may have restricted access to the tools and resources necessary for the successful implementation of Flexi 2.0. Insufficient resources may impede students' ability to utilize technology in practical contexts, hence obstructing their comprehension of its potential (Asmororini, Kinda & Sen, 2024; Habibi, Jiyane & Ozsen, 2024). Moreover, children from underprivileged schools may encounter greater challenges in accessing and utilizing Flexi 2.0 compared to their counterparts at well-resourced institutions, hence exacerbating the disparity in educational chances.

Integration with the Curriculum

Instructors encounter difficulties in aligning Flexi 2.0 with learning outcomes and instructional objectives while integrating it into the existing curriculum. Meticulous planning and coordination are essential to guarantee that the incorporation of an advanced manufacturing system such as Flexi 2.0 augments, rather than diminishes, the entire educational experience for students. Educators must develop instructional activities that cater to diverse student learning requirements and promote critical thinking and problem-solving abilities to effectively include Flexi 2.0 into the curriculum.

Modification to Shift

Students utilizing advanced technology such as Flexi 2.0 must exhibit adaptability and openness to novel ideas. Some youngsters may demonstrate resistance to change or experience discomfort when acclimating to a predominantly technology-driven educational setting. To assist students in surmounting their resistance to change and fostering a favorable disposition towards learning using Flexi 2.0, educators must provide unwavering support and encouragement. Educators must establish a safe and nurturing educational atmosphere that encourages students to experiment, investigate, and cultivate innovative concepts. Students will gain advantages as they transition seamlessly to Flexi 2.0.

Understanding Complex Outputs

Due to MathGPT's generation of explanations and solutions in colloquial English, students may encounter difficulties comprehending intricate mathematical ideas. Students may struggle to understand the processes that MathGPT employs to resolve a problem, particularly when confronted with complex mathematical ideas or advanced problem-solving methods.

Dependence on technology

Excessive reliance on MathGPT for solving mathematical problems may lead children to develop technology dependence. This may hinder students' capacity to develop critical thinking and problem-solving skills, as they can become reliant on MathGPT for solutions instead of actively participating in the problem-solving process (Iqbal, M., Farida, L. Z. N., & Win, K. T., 2023).

Verification and Validation

Although MathGPT strives to deliver precise solutions, students must still verify and validate the accuracy of the generated outputs. Students must possess a robust foundation in mathematics and critical thinking skills to assess the accuracy and coherence of the answers offered by MathGPT.

Integration with the Learning Process

Students must effectively employ MathGPT's functionalities to deepen their comprehension of mathematical ideas for its proper integration into the educational process. Nonetheless, many students may encounter difficulties in incorporating MathGPT into their standard curriculum and may necessitate support in mastering its application as an adjunct to conventional pedagogical approaches.

Security and Privacy Concerns

MathGPT is an online program, and students may have concerns regarding security and privacy, particularly when inputting private or sensitive information. By addressing these issues and safeguarding user data privacy and confidentiality, MathGPT can earn the respect and trust of pupils.

Educational Consistency

Educators must incorporate MathGPT into their lesson plans to augment the educational experiences of their pupils. To promote active learning and reinforce mathematical concepts, this entails creating educational exercises that utilize MathGPT's features. Nonetheless, obstacles may arise in the substantial integration of MathGPT into the curriculum, particularly if educators lack familiarity with the technology or are uncertain about incorporating it into existing lesson plans.

Quality Assurance

Ensuring the precision and dependability of MathGPT's outcomes is essential for educators. Before incorporating MathGPT solutions into lesson plans or assigning them to students, instructors must evaluate the quality of the responses and confirm their accuracy. Teachers must have a profound comprehension of the subject and the capacity to critically evaluate mathematical answers.

Promotion of Analytical Thought

It is essential to guarantee fair access to MathGPT for all pupils. Educators must take into account factors such as technological accessibility and internet connectivity while integrating MathGPT into their curricula. Moreover, educators must consider the requirements of students with disabilities and guarantee that MathGPT is accessible to all learners, irrespective of their specific educational demands.

Addressing Accessibility and Equity

Guaranteeing equitable access to MathGPT for all pupils is essential. Educators must take into account elements such as internet connectivity and technological accessibility while integrating MathGPT into their curricula. Educators are also required to consider the needs of students with disabilities and guarantee that MathGPT is accessible to all learners, irrespective of their specific learning requirements.

Opportunities

The subsequent potential were recognized in utilizing MathGPT and Flexi 2.0 as mathematical tutors for Calculus.

Convergence of Theory and Practice

MathGPT and Flexi 2.0 effectively connect classroom learning with real-world applications by enabling the synthesis of theoretical concepts and practical implementations. Flexi 2.0 enables students to integrate theoretical knowledge with practical application by utilizing mathematical principles acquired through MathGPT to address issues faced in the design and production process.

Advancement of Engaged Learning

MathGPT and Flexi 2.0 promote active learning by engaging students in interactive, inquiry-driven activities that encourage experimentation, investigation, and comprehension. Students engage in their education by doing independent inquiries and seeking solutions to real-world problems, so enhancing comprehension and knowledge retention.

Improvement of Problem-solving Abilities

Students acquire analytical reasoning, critical thinking, and problem-solving skills essential for success in academia and beyond by utilizing Flexi 2.0 to tackle real-world manufacturing challenges and MathGPT to resolve mathematical inquiries. By engaging in rigorous problem-solving, hypothesis testing, solution evaluation, and feedback-driven iteration, they cultivate a growth mindset and resilience in adversity (Sarnoko, S., Asrowi, A., Gunarhadi, G., & Usodo, B., 2024).

Preparation for Prospective Careers

The skills and competencies developed via the use of MathGPT and Flexi 2.0 align with the demands of the twenty-first-century workforce, where digital literacy, computational thinking, and proficiency in STEM disciplines are highly valued. MathGPT and Flexi 2.0 enhance economic growth and global competitiveness by offering STEM-related career preparation. The implications of this research align with recent studies promoting the integration of AI and technology in education. AI-driven technologies amalgamate theory and practice, enhancing students' ability to apply theoretical concepts to practical scenarios, hence fostering deeper understanding and critical analysis. The use of inquiry-driven learning technologies like MathGPT and Flexi 2.0 promotes active participation and improves knowledge retention (Kirschner et al., 2018).

Research further substantiates the improvement of problem-solving abilities using AI. AI-augmented educational environments improve students' analytical reasoning, critical thinking, and adaptability to real-world challenges (Grover & Pea, 2018). Moreover, iterative feedback and hypothesis testing foster a growth mindset and resilience, which are essential for academic success. The skills gained by AI tools—digital literacy, computational thinking, and STEM proficiency—are crucial for job preparedness in the 21st-century labor market (Li, Y., et.al, 2020; Putri & Turaqulov, 2022; Manlapig, 2024). Tools like MathGPT and Flexi 2.0 prepare students for STEM careers, which are increasingly in demand in the global economy (Dúo-Terrón, 2024). However, access to technology remains a limitation, as disparities in digital resources affect the effectiveness of these educational tools. Future endeavors must focus on addressing these inequalities to ensure equitable educational outcomes for all student groups.

CONCLUSION

This study's results highlight the transformative potential of AI-driven educational technologies like Flexi 2.0 and MathGPT in transforming conventional teaching approaches. Both systems exhibited substantial enhancements in students' arithmetic skills, underscoring their ability to address individual learning requirements, deliver tailored feedback, and promote a comprehensive grasp of intricate mathematical topics. Flexi 2.0 demonstrated marginally greater efficacy, indicating its suitability for the rising need of individualized instruction in modern education. The outcomes of this study facilitate the wider incorporation of AI-driven educational resources in diverse learning contexts, encompassing both conventional classrooms and virtual learning platforms. The effectiveness of these tools in enhancing student results underscores their capacity to render learning more interesting, productive, and customized to individual requirements. By utilizing these tools, educational institutions can enhance student preparedness for the requirements of a digital environment and elevate overall educational outcomes. This study underscores the significance of individualized learning enabled by AI, identifying tools such as Flexi 2.0 and MathGPT as crucial in improving instructional techniques. This could lead to the development of a new paradigm for AI-integrated education, wherein technologies are not merely supplemental but fundamental to tailored learning environments. Future research should investigate the long-term effects of AI integration on education and evaluate the potential for combining diverse AI technologies to address multiple academic subjects. Furthermore, educational institutions must guarantee that both students and educators are proficiently prepared to optimize the advantages of these tools, rendering AI an essential element of contemporary pedagogy.

ACKNOWLEDGMENTS

I express my sincere appreciation to everybody who contributed significantly to the completion of this study. I extend my profound gratitude to the University Administrators for permitting the execution of this research, as this undertaking would not have been feasible without their approval. I extend my heartfelt gratitude to the respondents who graciously dedicated their time and assistance throughout my fieldwork. I am particularly appreciative of my colleagues and students whose invaluable insights and support have enhanced the study process. Their contributions, regardless of magnitude, have been crucial in determining the results of this study. Finally, I express my sincere gratitude to all who have assisted me in any capacity, facilitating the smooth conclusion of this undertaking. Your contributions have been indispensable, and I am sincerely appreciative of your steadfast support and encouragement.

AUTHOR CONTRIBUTIONS

Joel I. Alvarez, the author, made substantial contributions to every facet of the research. He was accountable for the conceptualization and design of the study, encompassing the formulation of research questions and objectives. He directed the formulation of the experimental framework and the selection of AI-driven tools, specifically Flexi 2.0 and MathGPT. Mr. Alvarez supervised the data collection process, which included delivering pre-tests and post-tests, and performed statistical analysis to assess the efficacy of the AI technologies.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

REFERENCES

AL-Momani, M. O., AL-Momani, M. A. K., Hamadat, M. H., & Murtada, M. A. (2024). Distance e-learning and its impact on university education outcomes from the students' point of view. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *8*(1), 48-60. https://doi.org/10.22437/jiituj.v8i1.32116.

Alvarez, J. I. (2023). Massive open online course in elementary statistics: A tool in empowering data analysis for Philippine pre-service educators. *Asian Journal of Applied Education (AJAE)*, *2*(3), 515–528. https://doi.org/10.55927/ajae.v2i3.4260.

Alvarez, J. I. (2023). Relationship between mathematics beliefs and student engagement in mathematics as mediated by creative self-efficacy. *EPRA International Journal of Multidisciplinary Research (IJMR)*, *9*(3), 93-102. https://doi.org/10.36713/epra12481.

Alvarez, J. I., & Galman, A. S. M. A. (2023). Use of Filipino language as medium of instruction in teaching advanced algebra class. *European Journal of Science, Innovation and Technology, 3*(2), 157-171.

Alvarez, J. I., & Galman, S. M. A. (2023). HyFlex learning: Continuing tertiary education in a post-pandemic environment. *In Proceedings of the 3rd International Conference on Education and Technology (ICETECH 2022)* (pp. 584–601). Atlantis Press. https://doi.org/10.2991/978-2-38476-056-5_57.

Alvarez, J. I., & Galman, S. M. A. (2024). Utilizing digitalization in differentiation: Integration of Desmos in learning analytic geometry and calculus. *Galaxy International Interdisciplinary Research Journal, 12*(3), 127–140.

Angeles, J. R., & Alvarez, J. I. (2023). CMS 21: Integrating game-based learning in basic automotive. *EPRA International Journal of Research and Development (IJRD), 8*(3), 117–124. https://doi.org/10.36713/epra12664.

Asia, N., Kinda, J., & Edwards, J. (2024). Development of learning video media in biology subjects. *Tekno - Pedagogi : Jurnal Teknologi Pendidikan*, *14*(2), 9-14. https://doi.org/10.22437/teknopedagogi.v14i2.37486.

Asmororini, E., Kinda, J., & Sen, B. (2024). Innovation learning geography with ArcGIS online: The impact to skills collaborative and achievement student school upper intermediate. *Journal of Educational Technology and Learning Creativity*, *2*(1), 1-12. https://doi.org/10.37251/jetlc.v2i1.969.

Asrial, A., Syahrial, S., Kurniawan, D. A., Aldila, F. T., & Iqbal, M. (2023). Implementation of web-based character assessment on students' character outcomes: A review on perception and gender. *JOTSE: Journal of Technology and Science Education*, *13*(1), 301-328. https://doi.org/10.3926/jotse.1564.

Asrial, A., Syahrial, S., Kurniawan, D. A., Putri, F. I., Perdana, R., Rahmi, R., Susbiyanto, S., & Aldila, F. T. (2024). E-Assessment for Character Evaluation in Elementary Schools. *Qubahan Academic Journal*, *4*(3), 806-822. https://doi.org/10.48161/qaj.v4n3a595.

Baah, R., Konovalov, O., & Tenzin, S. (2024). Effectiveness of e-assessment in science learning: Improving the quality and efficiency of assessment in the digital era. *Integrated Science Education Journal*, *5*(2), 74-81. https://doi.org/10.37251/isej.v5i2.960.

Bray, A., & Tangney, B. (2017). Technology usage in mathematics education research—A systematic review of recent trends. *Computers & Education, 114*, 255–273. https://doi.org/10.1016/j.compedu.2017.07.002.

Cadiz, M. C. D., Manuel, L. A. F., Reyes, M. M., Natividad, L. R., & Ibarra, F. P. (2024). Technology integration in Philippine higher education: A content-based bibliometric analysis. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *8*(1), 35-47. https://doi.org/10.22437/jiituj.v8i1.31807.

Chen, C. J., & Liu, P. L. (2007). Personalized computer-assisted mathematics problem-solving program and its impact on Taiwanese students. *Journal of Computers in Mathematics and Science Teaching, 26*(2), 105–121. https://www.learntechlib.org/primary/p/22138/.

Chesani, F., Mello, P., & Milano, M. (2017). Solving mathematical puzzles: A challenging competition for AI. *AI Magazine, 38*(3), 83-96. https://doi.org/10.1609/aimag.v38i3.2736.

Civil, M., & Bernier, E. (2006). Exploring images of parental participation in mathematics education: Challenges and possibilities. *Mathematical Thinking and Learning, 8*(4), 309–330. https://doi.org/10.1207/s15327833mtl0804_2.

Cope, B., Kalantzis, M., & Searsmith, D. (2020). Artificial intelligence for education: Knowledge and its assessment in AI-enabled learning ecologies. *Educational Philosophy and Theory, 53*(12), 1229-1245. https://doi.org/10.1080/00131857.2020.1728732.

Dúo-Terrón, P. (2024). Generative artificial intelligence: Educational reflections from an analysis of scientific production. *Journal of Technology and Science Education,* 14(3), 756-769. https://doi.org/10.3926/jotse.2680.

Ee, J., & Nan, H. (2018). A study on the relationship between artificial intelligence and change in mathematics education. *Communications of Mathematical Education*, *32*(1), 23–36. https://doi.org/10.7468/jksmee.2018.32.1.23.

Fitriana, H., & Waswa, A. N. (2024). The influence of a realistic mathematics education approach on students' mathematical problem solving ability. *Interval: Indonesian Journal of Mathematical Education*, *2*(1), 29-35. https://doi.org/10.37251/ijome.v2i1.979.

Grover, S., & Pea, R. (2018). Computational thinking: A competency whose time has come. *In Bloomsbury Academic eBooks*. https://doi.org/10.5040/9781350057142.ch-003.
Habibi, M. W., Jiyane, L., & Ozsen, Z. (2024). Learning revolution: The positive impact of computer simulations on science achievement in madrasah ibtidaiyah. *Journal of Educational Technology and Learning Creativity*, *2*(1), 13-19. https://doi.org/10.37251/jetlc.v2i1.976.
Hwang, G.-J., & Tu, Y.-F. (2021). Roles and research trends of artificial intelligence in mathematics education: A bibliometric mapping analysis and systematic review. Mathematics, 9(6), 584. https://doi.org/10.3390/math9060584.
Iqbal, M., Farida, L. Z. N., & Win, K. T. (2023). The influence of student attitudes on learning achievement. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *7*(2), 92-98. https://doi.org/10.22437/jiituj.v7i2.26697.
Kirschner, P. A., Sweller, J., & Clark, R. E. (2018). Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching. *Educational Psychologist*, *41*(2), 75–86. https://doi.org/10.1207/s15326985ep4102_1.
Kutyniok, G. & International Mathematical Union. (2022). The mathematics of artificial intelligence. In *Proc. Int. Cong. Math. 2022* (Vol. 7, pp. 5118–5139). EMS Press. https://doi.org/10.4171/ICM2022/141.
Li, Y., Schoenfeld, A. H., diSessa, A. A., Graesser, A. C., Benson, L. C., English, L. D., & Duschl, R. A. (2020). On computational thinking and STEM education. *Journal for STEM Education Research*, *3*(2), 147–166. https://doi.org/10.1007/s41979-020-00044-w.
Manlapig, E. (2024). Enhancing student learning motivation in physics through interactive physics education technology (PhET) simulation. *Schrödinger: Journal of Physics Education*, *5*(3), 88-97. https://doi.org/10.37251/sjpe.v5i3.1025.
Mardiati, D. C., Alorgbey, B., & Zarogi, A. B. (2024). The relationship between educational level and the role of parents with learning achievement in mathematics. *Interval: Indonesian Journal of Mathematical Education*, *2*(1), 22-28. https://doi.org/10.37251/ijome.v2i1.983.
Marta, P., Khairinal, K., & Murbojono, R. (2023). Innovative approaches: Unveiling integrated social sciences learning at SMP Negeri 7 Muaro Jambi. *Tekno - Pedagogi : Jurnal Teknologi Pendidikan*, *13*(1), 41-49. https://doi.org/10.22437/teknopedagogi.v13i1.32541.
Mizian, Z. (2023). Development of an electronic brick bonding module using the autocad program for students. *Tekno-Pedagogi: Jurnal Teknologi Pendidikan*, *13*(2), 35-43. https://doi.org/10.22437/teknopedagogi.v13i2.32531.
Mohamed, M. Z. B., Hidayat, R., Suhaizi, N. N. B., Sabri, N. B. M., Mahmud, M. K. H. B., & Baharuddin, S. N. B. (2022). Artificial intelligence in mathematics education: A systematic literature review. *International Electronic Journal of Mathematics Education*, *17*(3), em0694. https://doi.org/10.29333/iejme/12132.
Nazaretsky, T., Ariely, M., Cukurova, M., & Alexandron, G. (2022). Teachers' trust in AI-powered educational technology and a professional development program to improve it. *British Journal of Educational Technology*, *53*(4), 914-931. https://doi.org/10.1111/bjet.13232.
Nehru, N., Purwaningsih, S., Riantoni, C., Ropawandi, D., & Novallyan, D. (2024). Mapping students' thinking systems in critical thinking based on stem project-based learning experiences. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *8*(1), 136-144. https://doi.org/10.22437/jiituj.v8i1.32027.
Owan, V. J., Abang, K. B., Idika, D. O., Etta, E. O., & Bassey, B. A. (2023). Exploring the potential of artificial intelligence tools in educational measurement and assessment. *EURASIA Journal of Mathematics, Science and Technology Education*, *19*(8). https://doi.org/10.29333/ejmste/13428.
Perdana, F. A., Zakariah, S. H., & Alasmari, T. (2023). Development of learning media in the form of electronic books with dynamic electricity teaching materials. *Journal of Educational Technology and Learning Creativity*, *1*(1), 1-6. https://doi.org/10.37251/jetlc.v1i1.619.
Popenici, S. A., & Kerr, S. (2017). Exploring the impact of artificial intelligence on teaching and learning in higher education. *Research and Practice in Technology Enhanced Learning*, *12*(22), 1-13. https://doi.org/10.1186/s41039-017-0062-8.
Putri, D. S. I., & Turaqulov, B. T. (2022). Harmonizing tradition, science, and STEM learning: Empowering students' creative minds with sound waves and local wisdom. *Schrödinger: Journal of Physics Education*, *3*(4), 90-98. https://doi.org/10.37251/sjpe.v3i4.916.

Saputro, H. D., Rustaminezhad, M. A., Amosa, A. A., & Jamebozorg, Z. (2023). Development of e-learning media using adobe flash program in a contextual learning model to improve students' learning outcomes in junior high school geographical research steps materials. *Journal of Educational Technology and Learning Creativity*, *1*(1), 25-32. https://doi.org/10.37251/jetlc.v1i1.621.

Sari, R., Omeiza, I. I., & Mwakifuna, M. A. (2023). The influence of number dice games in improving early childhood mathematical logic in early childhood education. *Interval: Indonesian Journal of Mathematical Education*, *1*(2), 61-66. https://doi.org/10.37251/ijome.v1i2.776.

Sarnoko, S., Asrowi, A., Gunarhadi, G., & Usodo, B. (2024). An analysis of the application of problem-based learning (PBL) model in mathematics for elementary school students. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *8*(1), 188-202. https://doi.org/10.22437/jiituj.v8i1.32057.

Setiyani, E. N., Panomram, W., & Wangdi, T. (2024). Development of predict observe explain based flat side building worksheets to improve students' mathematical representation skills. *Interval: Indonesian Journal of Mathematical Education*, *2*(1), 15-21. https://doi.org/10.37251/ijome.v2i1.984.

Triyasmina, T., Rusdi, M., Asyhar, R., Dachia, H. A., & Rukondo, N. (2022). Chemistry learning revolution: Interactive multimedia e-learning with a problem based learning approach. *Tekno-Pedagogi: Jurnal Teknologi Pendidikan*, *12*(2), 1-9. https://doi.org/10.22437/teknopedagogi.v12i2.32521.

Van Vaerenbergh, S., & Pérez-Suay, A. (2022). A Classification of Artificial Intelligence Systems for Mathematics Education. In: Richard, P.R., Vélez, M.P., Van Vaerenbergh, S. (eds) Mathematics Education in the Age of Artificial Intelligence. *Mathematics Education in the Digital Era*, *17*. Springer, Cham. https://doi.org/10.1007/978-3-030-86909-0_5.

Yohanie, D. D., Botchway, G. A., Nkhwalume, A. A., & Arrazaki, M. (2023). Thinking process of mathematics education students in problem solving proof. *Interval: Indonesian Journal of Mathematical Education*, *1*(1), 24-29. https://doi.org/10.37251/ijome.v1i1.611.

Zakiyah, Z., Boonma, K., & Collado, R. (2024). Physics learning innovation: Song and animation-based media as a learning solution for mirrors and lenses for junior high school students. *Journal of Educational Technology and Learning Creativity*, *2*(2), 54-62. https://doi.org/10.37251/jetlc.v2i2.1062.