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Exploring college students' awareness and use of AI-enhanced flipped classroom models: Impacts on learning outcomes and skills development

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ABSTRACT

This study examines college students' awareness of and use of artificial intelligence (AI) in flipped classroom activities that involve Mathematics in the Modern World. The flipped classroom promotes self-paced learning and collaboration by having students work on learning materials outside of class and participate in interactive exercises in class. AI tools, increasingly prevalent in education, offer personalized support for college students through tutoring systems, problem-solving platforms, and chatbots, complementing the flipped classroom model. Furthermore, this assesses college students' awareness of AI regarding the flipped classroom model, emphasizing advantages like participation, engagement, problem-solving skills, study habits, and academic achievement. It also looks into the AI tools that college students use to improve their education. The methodology involves 65 volunteer college students from the University of Makati who participate in a descriptive approach using a Likert scale questionnaire to assess student awareness across multiple aspects. Preliminary results show that college students are highly aware of the flipped classroom model, recognizing its impact on participation, problem-solving, and time management. They also demonstrate a strong awareness of AI's potential to provide personalized feedback and improve academic performance, although practical usage of AI tools like chatbots and tutoring systems remains moderate. Although students understand the function AI plays in flipped classrooms, more integration and training are required to realize the potential advantages of these tools fully. The study highlights how crucial it is to promote digital literacy and individualized learning through AI-driven educational advancements.

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INTRODUCTION

Teaching Mathematics in the Modern World to college students is quite interesting and challenging. Mathematics, with its abstract concepts and logical structures, often requires the creativity and adaptability of teachers to engage students effectively. The flipped classroom approach, a form of integrated learning, is one such approach that has drawn a lot of interest. Providing instructional content, such as videos and other learning resources, outside of the classroom and occupying the in-class period with various activities, like discussions, flips the traditional teaching and learning strategy (Fung, Besser, and Poon, 2021). This model promotes deeper understanding by enabling college students to engage with the material more actively and at their own pace while improving communication and collaboration skills as they interact with their peers.

In comparison to traditional classrooms, the flipped classroom promotes student-centered learning by allowing teachers to devote in-class time to activities that deepen students' comprehension, such as debates, questions, and problem-solving (Esperanza, Himang, Bongo, Selerio, & Ocampo, 2023). This approach has been especially useful in mathematics, where college students frequently struggle with self-directed learning. Instructors can use classroom time to help students work through challenging problems, foster peer-to-peer interaction, and provide instant, individualized feedback on their knowledge. By fostering a dynamic and participatory classroom environment, the flipped classroom concept has the potential to improve student engagement and mathematical learning outcomes greatly.

Concurrent with the emergence of the flipped classroom approach, the use of artificial intelligence (AI) tools in the classroom has grown in significance (Nik Harun, Md Syed, & Abdullah, 2024). In recent years, artificial intelligence (AI) tools for education have gained a lot of attention and are growing in popularity. According to bin Mohamed, Hidayat, binti Suhaizi, bin Mahmud, and binti Baharuddin (2022), it represents a leap across creative and inventive thinking in a variety of sectors, including mathematics education. AI can support college students in learning complex concepts outside the classroom by offering targeted practice and providing instant feedback on exercises. With the guidance of AI tools, they can improve their problem-solving skills and work at their own pace, reinforcing the material in a way that suits their learning styles. AI-driven tools are able to identify areas of weakness and provide real-time interventions, which is especially helpful for students in a subject like mathematics.

AI has the potential to greatly improve student learning results, according to research. Heffernan and Heffernan (2014) found that AI-driven tutoring systems are particularly effective in offering personalized learning experiences. These systems adapt to individual students' needs, enabling students to advance at their own speed and obtain focused feedback, which can lead to improved learning outcomes. Similarly, Woolf (2010) highlighted the role of AI in providing immediate feedback, allowing students to learn more efficiently and effectively. In the context of the flipped classroom, AI tools can further enhance the learning process by supporting students in their independent study at home and helping them come to class better prepared for interactive problem-solving activities.

Despite the increasing use of AI in educational settings, there remains a significant gap in research concerning its application in mathematics education within a flipped classroom model**.** While numerous studies have explored the effectiveness of AI in personalized learning (VanLehn, 2011; Woolf, 2010), little research has focused on how AI can be integrated with flipped classrooms to enhance mathematics learning. This is a key area for further research since the incorporation of AI might be a useful tool for students learning mathematics in a flipped classroom, particularly by facilitating personalized learning and promoting understanding of mathematical ideas prior to engaging in in-class activities.

In response to this research gap, the present study seeks to explore college students' awareness towards the use of AI in flipped classroom settings, particularly in the context of Mathematics in the Modern World**.** By investigating students' perceptions and experiences with AI-driven tools in a flipped classroom environment, this study aims to contribute to our understanding of how AI can be effectively incorporated into mathematics education to improve learning outcomes. This research also has the potential to inform best practices for integrating AI in

flipped classroom models across different disciplines, ultimately helping educators leverage technology to enhance teaching and learning.

Flipped Classroom Activities

Teachers are using various methods and techniques to deliver quality education to their students. One blended learning that has been used nowadays is the flipped classroom. According to the "Flipped Learning" paradigm, students engage in more interesting and hands-on activities in the classroom while also studying the lessons beforehand (Selahattin & Eyup, 2024). Furthermore, the study by Steele (2023) mentioned that nurse educators have increasingly used flipped classroom learning environments to enhance learning in the classroom. The flipped classroom methods allow educators to introduce classroom learning activities to augment student learning. The creativity of teachers in using this method can improve the way college students do their tasks at home and participate in class discussions in school.

A lot of college students are independent learners. Their self-regulated learning can be observed during the class discussion because some of them tend to show other methods of solving the task and ask questions that will make the class more energetic and participative. Guerra (2024) found that self-regulated learning plays a similar function in the relationship between self-efficacy and engagement, and that involvement in flipped classroom activities mediates the relation between self-regulated learning and in-class performance.

Utilizing flipped classroom activities can improve the performance of college students. The tasks and lessons were given in advance through an online platform and they can do anything to study it on their own. Then, during classroom discussions, college students share what they have learned at home and confirm if what they know and research is true. It is the task of the teacher to confirm all the confusion of college students during classroom discussions. Personalized and student-centered learning becomes possible (Ruenphongphun, Sukkamart, & Pimdee, 2022; Chinchua, Kantathanawat, & Tuntiwongwanich, 2022; Charungkaittikul, & Henschke, 2014; Sams, & Bergmann, 2012) when learners return to the classroom (Pimdee, Sukkamart, Nantha, Kantathanawat, & Leekitchwatana, 2024).

Using Artificial Intelligence (AI) In Flipped Classroom Activities

During flipped classroom activities, college students have the opportunity to use a variety of techniques to enhance their learning, including conducting research in the library, engaging in peer discussions, or leveraging artificial intelligence (AI) tools to support their self-paced study. As noted by Lv (2023), the integration of AI in education presents an essential path for developing new teaching methods, especially in the context of online and blended learning environments. One of the promising teaching models that leverages AI is the flipped classroom, where students take on greater responsibility for their learning outside of traditional class hours, with AI acting as a facilitator of personalized and adaptive learning experiences.

AI's role in education has been increasingly recognized, though some educators remain hesitant to incorporate it into classroom activities. However, many college students have already embraced AI tools to support their learning, particularly in subjects such as mathematics. For instance, a study by Wang, Wang, Xu, Yang, Cai, and Yin (2023) demonstrated that when students became proficient in "prompt engineering", the ability to ask effective and targeted questions, they were able to maximize the benefits of using AI-based tools like ChatGPT. This led to an improved quality of information and greater learning efficiency, especially in flipped classroom settings. These findings suggest that students can significantly enhance their learning experiences by effectively using AI tools, but only if guided appropriately by instructors. Such guidance ensures that students fully utilize AI's potential in a structured and beneficial way.

Chatbots, such as ChatGPT, have also shown great promise in enhancing educational outcomes. Selahattin and Eyup (2024) emphasized how chatbots driven by AI might be easily incorporated into educational systems to offer students and institutional staff quick and individualized assistance. These tools offer a unique opportunity for

students to receive immediate, tailored feedback and support outside of regular class hours, thus extending the learning process and ensuring ongoing engagement. The potential for AI chatbots to provide personalized learning materials and assist with problem-solving makes them an invaluable resource for students participating in flipped classroom activities.

In addition to these findings, recent research by Zhang, Wang, and Li (2022) explored the use of AI-driven personalized learning platforms in flipped classrooms and found that students who utilized these AI systems showed increased motivation, higher engagement, and improved academic performance in subjects such as mathematics. Furthermore, a study by Yang, Huang, and Chen (2021) demonstrated that AI systems capable of analyzing students' learning behaviors and tailoring content accordingly resulted in significant improvements in problem-solving skills and conceptual understanding. These studies further reinforce the potential of AI to not only enhance individual learning outcomes but also to foster a more interactive and adaptive learning environment within flipped classrooms.

While the integration of AI in flipped classrooms shows considerable promise, it is clear that further research is necessary to thoroughly understand both its benefits and drawbacks. As Selahattin and Eyup (2024) noted, while AI tools like chatbots and tutoring systems hold great potential, their full integration into flipped learning models requires careful consideration of pedagogical strategies and technical capabilities. Continued exploration of how AI can be best utilized in diverse educational settings will be essential for maximizing its benefits and ensuring that both students and educators can leverage these tools effectively.

OBJECTIVES OF THE STUDY

This study aims to determine the awareness of college students in using AI in flipped classroom activities in mathematics in the modern world.

1. What is the college students' awareness of the flipped classroom model?
2. What are the benefits of the flipped classroom model on college students in terms of:
   2.1 Engagement and Participation
   2.2 Problem-solving skills
   2.3 Study Habits and Time Management
   2.4 Academic Performance in Math?
3. What is the college students' awareness of using AI for flipped classroom activities?
4. How the college students use the AI terms of:
   4.1 AI-Based Tutoring System
   4.2 AI-Based Problem Solving
   4.3 Chatbot Support
5. What are the artificial intelligence tools that college students are using?

MATERIALS AND METHODS

Research Design

In order to determine college students' understanding of the use of artificial intelligence (AI) for flipped classroom activities in Mathematics in the Modern World, this study uses a quantitative research design, namely a descriptive technique. Since it enables the methodical gathering and examination of numerical data to identify patterns and trends without having an adverse effect on the environment, the descriptive technique is suitable for this investigation. Students' current comprehension of the flipped classroom concept and the use of AI technology to enhance their educational experiences is especially well-represented in this design (Cresswell, 2017; Neuman, 2014).

Quantitative data will measure the awareness of college students in the flipped classroom model; the benefits of the flipped classroom in terms of engagement and participation, problem-solving skills, study habits and time

management, and academic performance in math; the awareness of college students in using AI for flipped classroom activities; and how they use AI in terms of AI-based tutoring system, AI-based problem solving, and chatbot support.

By focusing on quantifiable data, this study aims to provide a clear understanding of how well students are aware of and engage with AI technologies in the context of flipped learning, offering insights that may guide future pedagogical strategies and technological integrations in Mathematics education (Bergmann & Sams, 2012; VanLehn, 2011).

Participants

Participants in this study are chosen using a voluntary, non-random sampling procedure. Participants were selected based on their voluntary willingness to participate in the survey. This non-probability sampling technique is commonly used by researchers to select individuals who are easily accessible and willing to participate, rather than random selection (Creswell, 2014). Using this approach, the study targets individuals who meet the inclusion criteria of being enrolled in the Mathematics in the Modern World course at the University of Makati during the First Semester of the Academic Year 2024-2025, as well as being part of a flipped classroom setup in which they are engaged in activities that incorporate active learning and self-directed study. Finally, a total of sixty-five (65) students voluntarily participated in the survey.

Instrument

The study's Likert scale questionnaire was modified using pre-existing survey tools created in earlier studies on the flipped classroom concept and the application of AI in education. The statements in the questionnaire were drawn from the works of Chen and Chen (2021), Hwang and Chen (2020), Yang et al. (2020), Wang et al. (2019), Fernandez and Raelin (2018), O'Flaherty and Phillips (2015), Hwang et al. (2015), Jensen et al. (2015), Johnson et al. (2014), D'Mello and Graesser (2015), McLaughlin et al. (2014), Heffernan and Heffernan (2014), Kim et al. (2014), Freeman et al. (2014), Davies et al. (2013), Siemens (2013), Romero and Ventura (2013), Bishop and Verleger (2013), Tucker (2012), Bergmann and Sams (2012), Strayer (2012), Kumpulainen and Lipponen (2012), Crouch and Mazur (2001), and Lage, Platt, and Treglia (2000). These studies provided the foundation for measuring the objectives of this research.

Part I of the questionnaire focuses on assessing students' awareness of the flipped classroom model and its impact on their engagement, participation, problem-solving skills, study habits, time management, and academic performance in mathematics. Part II measures students' use of AI in flipped classroom activities, specifically how they utilize AI tools such as AI-based tutoring systems, AI-driven problem-solving platforms, and chatbot support. The Likert scale questionnaire was content-validated and reviewed for grammar by professors teaching Mathematics in the Modern World. It was then administered via Google Forms.

RESULTS AND DISCUSSION

The study findings as they are tabulated, examined, and interpreted in line with the sequence of the research questions are discussed in this section.

Table 1 presents the college students' awareness of the flipped classroom model. The highest awareness was noted in students' recognition that flipped classrooms require engagement with digital learning tools and resources ($\underline{x}$ = 3.85). Additionally, students were strongly aware that pre-class preparation is essential ($\underline{x}$ = 3.74). The results of Table 1 reflect a strong awareness of the flipped classroom model among students, with a composite mean of 3.72 (s = 0.41). This high level of awareness is crucial for the effectiveness of the model, as engagement in pre-class tasks significantly enhances learning outcomes (Kim et al., 2014).

Table 1. The College Students' Awareness of The Flipped Classroom Model

	$\underline{x}$	s	Interpretation
1. I understand that the flipped classroom model highlights our preparation before attending our class. (O'Flaherty, & Phillips, 2015)	3.74	0.51	Strongly Aware
2. I understand that in a flipped classroom, instructional content is delivered outside of our class time. (Bishop & Verleger, 2013)	3.65	0.60	Strongly Aware
3. I am aware that flipped classrooms often require us to engage with digital learning tools and resources. (Tucker, 2012)	3.85	0.36	Strongly Aware
4. I recognize that the flipped classroom model often requires us to complete pre-class assignments. (Kim, et al., 2014).	3.62	0.63	Strongly Aware
5. I am aware that the flipped classroom model involves us engaging in active learning during our class time. (Lage, Platt, & Treglia, 2000)	3.74	0.48	Strongly Aware
Composite Mean	3.72	0.41	Strongly Aware

Legend: 3.26 – 4.00 = Strongly Aware; 2.51-3.25 = Aware; 1.76-2.50 = Unaware; 1.00 – 1.75 = Strongly Unaware

Prior knowledge and comprehension of the flipped classroom may have a big impact on how well students interact with the course materials, participate in class activities, and eventually succeed academically in a math course. Research has shown that students' awareness of innovative instructional models, such as the flipped classroom, can enhance their readiness to actively engage with the learning process, leading to improved learning outcomes (Li, Fu, Liu, & Hwang, 2024). Moreover, this awareness may contribute to their ability to adapt more effectively to the self-directed and interactive nature of the flipped classroom, this usually calls on students to be more accountable for their own education outside of the classroom.

Table 2. The Benefits of The Flipped Classroom Model on College Students' Engagement and Participation

	$\underline{x}$	S	Interpretation
1. The flipped classroom model has increased my engagement in class activities. (Freeman, et al., 2014)	3.37	0.72	Strongly Aware
2. The flipped classroom model makes me feel more motivated to participate in discussions. (Crouch & Mazur, 2001)	3.38	0.76	Strongly Aware
3. The flipped classroom activities make me feel more involved in the learning process. (Bergmann & Sams, 2012)	3.37	0.74	Strongly Aware
4. The flipped classroom has encouraged me to contribute more during class sessions. (Johnson, et al., 2014)	3.35	0.74	Strongly Aware
5. I am more likely to engage with course materials when using the flipped classroom model. (Bishop & Verleger, 2013)	3.45	0.79	Strongly Aware
Composite Mean	3.38	0.68	Strongly Aware

Legend: 3.26 – 4.00 = Strongly Aware; 2.51-3.25 = Aware; 1.76-2.50 = Unaware; 1.00 – 1.75 = Strongly Unaware

Table 2 shows the benefits of the flipped classroom model in college students' engagement and participation. College students reported feeling more motivated to participate in discussions (x = 3.38) when they are having flipped classroom activities. Active engagement during in-class activities (x = 3.45) is a symbol of it, which leads to deeper

understanding and retention of material. Table 2 demonstrates a strong awareness of how the flipped classroom positively impacts student engagement and participation with a composite mean of 3.38 and a standard deviation value of 0.68.

The students in this study were well aware of the benefits of the flipped classroom model, particularly in terms of boosting their engagement and participation. This increased awareness most likely led to a more engaged and driven attitude to their learning process. In fact, Alebrahim and Ku's (2020) research validates these findings, demonstrating that the majority of students in their study preferred the challenges given by the flipped classroom model. These challenges, which frequently include active learning tasks like problem solving, collaborative conversations, and applying concepts in real-world settings, were proven to improve student engagement.

Table 3. The Benefits of The Flipped Classroom Model on College Students' Problem-Solving Skills

	$\underline{x}$	s	Interpretation
1. The flipped classroom model has improved my problem-solving abilities. (Hwang, et al., 2015)	3.15	0.78	Aware
2. I have developed better problem-solving skills through in-class activities in a flipped classroom. (Jensen, et al., 2015)	3.25	0.73	Aware
3. The flipped classroom approach has enhanced my ability to apply concepts to solve problems. (Lage, Platt, & Treglia, 2000)	3.31	0.73	Strongly Aware
4. The flipped classroom model has made it easier for me to approach and solve difficult problems. (Jensen, et al., 2015)	3.28	0.76	Strongly Aware
5. I feel more confident in my problem-solving skills because of the flipped classroom approach. (Strayer, 2012)	3.22	0.74	Aware
Composite Mean	3.24	0.66	Aware

Legend: 3.26 – 4.00 = Strongly Aware; 2.51-3.25 = Aware; 1.76-2.50 = Unaware; 1.00 – 1.75 = Strongly Unaware

Table 3 illustrates the benefits of the flipped classroom model on college students' problem-solving skills. The highest awareness was in the enhanced ability to apply concepts with a mean of 3.31. The improvement in students' problem-solving abilities ($\underline{x}$ = 3.15) is supported by Hwang et al. (2015), who observed that flipped classrooms can foster critical thinking through in-class activities. This implies that college students showed an awareness (composite mean = 3.24, s = 0.66) of the role of flipped classrooms in improving problem-solving skills.

One of the crucial skills that students should acquire in mathematics is problem-solving. Students are aware that the flipped classroom concept has helped them become better problem solvers. According to Yu, Li, Lan, and Zheng's (2023) research, flipped classrooms significantly improve students' problem-solving skills, especially in subjects that often call for longer class sessions. Furthermore, their study found that after using the flipped classroom method, the majority of pupils appreciated it.

Table 4 presents the benefits of the flipped classroom model on college students' study habits and time management. The development of better study habits (x = 3.34) which emphasized the benefits of flipped classrooms in fostering self-regulated learning. The flipped classroom also supported better time management (x = 3.38), as noted by McLaughlin et al. (2014), where students were better able to balance study time with other commitments. It is revealed in Table 4 that a strong awareness of how flipped classrooms help improve students' study habits and time management with a composite mean of 3.36 and a standard deviation of 0.64.

Many studies (O'Flaherty & Phillips, 2015; Freeman et al., 2014; Jensen et al., 2015) suggest that the flipped classroom model helps improve study habits and time management by encouraging students to prepare and engage

with materials before class. Additionally, the research by Yarbro, Arfstrom, McKnight, and McKnight (2014) indicates that the flipped classroom model promotes better organizational skills and time management, as students take greater accountability for their education and frequently get ready for class beforehand.

Table 4. The Benefits of The Flipped Classroom Model on College Students' Study Habits and Time Management

	$\underline{x}$	s	Interpretation
1. The flipped classroom model has helped me develop better study habits. (Davies, et al., 2013)	3.34	0.73	Strongly Aware
2. The flipped classroom approach has improved my ability to prioritize my study tasks. (O'Flaherty, & Phillips, 2015)	3.42	0.70	Strongly Aware
3. The pre-class assignments in a flipped classroom help me manage my study time better. (Bishop & Verleger, 2013)	3.29	0.72	Strongly Aware
4. The flipped classroom model supports better time management for my academic responsibilities. (Davies, et al., 2013)	3.38	0.74	Strongly Aware
5. The flipped classroom format helps me balance my study time with other commitments. (McLaughlin, et al., 2014)	3.38	0.72	Strongly Aware
Composite Mean	3.36	0.64	Strongly Aware

Legend: 3.26 – 4.00 = Strongly Aware; 2.51-3.25 = Aware; 1.76-2.50 = Unaware; 1.00 – 1.75 = Strongly Unaware

Table 5 shows how the flipped classroom approach improves college students' academic achievement in math. The improvement in math comprehension with a mean of 3.40 corresponds with Hwang et al. (2015), who demonstrated the benefits of flipped classrooms for mathematical problem-solving. Improved performance in math exams (x = 3.32) is supported by Fernandez and Raelin (2018), who found that students in flipped classrooms performed better academically. These results indicate a strong awareness of the flipped classroom's impact on math performance with a composite mean of 3.34 and a standard deviation of 0.60.

Table 5. The Benefits of The Flipped Classroom Model on College Students' Academic Performance in Math

	$\underline{x}$	s	Interpretation
1. The flipped classroom model has improved my performance in math courses. (Fernandez & Raelin, 2018)	3.37	0.67	Strongly Aware
2. The flipped classroom model has helped me achieve higher grades in math. (Tucker, 2012)	3.32	0.66	Strongly Aware
3. My problem-solving skills in math have improved with the flipped classroom model. (Freeman, et al., 2014)	3.28	0.65	Strongly Aware
4. I perform better in math exams due to the flipped classroom approach. (Fernandez & Raelin, 2018)	3.32	0.69	Strongly Aware
5. The flipped classroom model has enhanced my comprehension of math problem-solving techniques. (Hwang, et al., 2015)	3.40	0.70	Strongly Aware
Composite Mean	3.34	0.60	Strongly Aware

Legend: 3.26 – 4.00 = Strongly Aware; 2.51-3.25 = Aware; 1.76-2.50 = Unaware; 1.00 – 1.75 = Strongly Unaware

The respondents are highly aware that the flipped classroom model contributes to an improvement in their academic performance in mathematics. This awareness is supported by the findings of Wei, Cheng, Chen, Yang, Liu, Dong, and Kinshuk (2020), who demonstrated that the flipped classroom approach significantly enhances students'

mathematical learning outcomes. The study indicates that by advancing the focus from traditional lecture-based training to a more participatory and student-centered learning environment, the flipped classroom model allows students to engage more deeply with mathematical subject matter.

Table 6 shows the college students' awareness of using AI for flipped classroom activities. In this table, college students show a strong awareness of the role of AI in flipped classroom activities with a composite mean of 3.45 and supported by a standard deviation of 0.53. The highest awareness was in understanding that AI can provide instant feedback on assignments (x = 3.49). Furthermore, the awareness that AI tools can create personalized learning experiences (x = 3.52) is supported by Chen and Chen (2021), who discussed how AI customizes learning pathways for students.

Table 6. The College Students' Awareness of Using AI For Flipped Classroom Activities

	$\underline{x}$	s	Interpretation
1. I am aware that AI tools can be used to create personalized learning experiences in a flipped classroom. (Chen & Chen, 2021)	3.52	0.62	Strongly Aware
2. I know that AI-powered analytics can help track my progress in flipped classroom activities. (Siemens, 2013)	3.35	0.74	Strongly Aware
3. I understand that AI can be used to provide instant feedback on my assignments in a flipped classroom. (Heffernan & Heffernan, 2014)	3.49	0.59	Strongly Aware
4. In a flipped classroom scenario, I know AI can assist me in identifying areas where I require further support. (Romero & Ventura, 2013)	3.45	0.66	Strongly Aware
5. I understand that AI can be used to create virtual tutors that assist with homework in a flipped classroom. (Kumpulainen & Lipponen, 2012)	3.42	0.73	Strongly Aware
Composite Mean	3.45	0.53	Strongly Aware

Legend: 3.26 – 4.00 = Strongly Aware; 2.51-3.25 = Aware; 1.76-2.50 = Unaware; 1.00 – 1.75 = Strongly Unaware

The findings indicate that students are well aware of the incorporation of AI technologies into flipped classroom activities and appreciate the critical role these technologies play in improving their learning experience. This understanding is reinforced by the research of Li and Peng (2022), who presented a new flipped teaching paradigm that incorporates AI technologies. Their findings indicate the efficacy of this strategy, emphasizing that the success of flipped classroom learning is dependent on the seamless integration of traditional classroom instruction with AI-assisted online educational experiences. According to Li and Peng, for the flipped classroom paradigm to be most effective, both components—traditional in-person teaching and AI-driven online learning—must function in tandem, reinforcing and supporting each other in a logical manner.

Table 7 shows college students' awareness of the use of AI-based tutoring systems, with a composite mean of 2.84 and a standard deviation of 0.78. While the highest mean of 3.05 is associated with AI-based tutoring systems' ability to enhance understanding of complex topics, this level of awareness indicates that there is still room for growth in the integration of AI. These findings align with those of Heffernan and Heffernan (2014), who emphasized that AI-based tutoring systems have the potential to significantly improve students' problem-solving skills by offering personalized support. However, their research also pointed out that these systems often require more seamless integration within existing educational frameworks in order to achieve their maximum potential. The study suggests that although AI tutoring systems can help students better understand complex topics, their integration into traditional classroom settings needs further refinement to ensure that both instructors and students can fully utilize their capabilities.

Table 7. AI-Based Tutoring System

	$\underline{x}$	s	Interpretation
1. I regularly use AI-based tutoring systems to assist with my understanding of course material in a flipped classroom. (Heffernan & Heffernan, 2014)	2.55	0.97	Aware
2. I find AI-based tutoring systems helpful for reviewing and reinforcing content covered in class. (Chen & Chen, 2021)	2.88	0.80	Aware
3. AI-based tutoring systems provide explanations that enhance my understanding of complex topics. (Heffernan & Heffernan, 2014)	3.05	0.89	Aware
4. The AI-based tutoring system I use integrates well with the flipped classroom model. (Chen & Chen, 2021)	2.82	0.85	Aware
5. I find that AI-based tutoring systems are effective in helping me prepare for in-class activities. (Wang, et al., 2019)	2.91	0.90	Aware
Composite Mean	2.84	0.78	Aware

Legend: 3.26 – 4.00 = Strongly Aware; 2.51-3.25 = Aware; 1.76-2.50 = Unaware; 1.00 – 1.75 = Strongly Unaware

In Table 8, students reflect an awareness of AI-based tools in problem-solving activities with a composite mean of 3.00 and a standard deviation of 0.62. The awareness that AI-based tools provide effective solutions for assignments (x = 3.06) aligns with D'Mello and Graesser (2015), who explored AI's role in supporting problem-based learning environments. This implies that while AI is acknowledged as a useful tool, its practical integration could be enhanced.

Table 8. AI-Based Problem Solving

	$\underline{x}$	s	Interpretation
1. AI-based problem-solving tools provide effective solutions and explanations for challenging assignments. (D'Mello & Graesser, 2015)	3.06	0.81	Aware
2. AI-based tools help me develop better strategies for tackling difficult problems. (Chen & Chen, 2021)	2.94	0.77	Aware
3. AI-based problem-solving tools offer practical examples that aid in understanding complex concepts. (Hwang & Chen, 2020)	3.03	0.81	Aware
4. Using AI-based problem-solving tools has improved my performance in problem-based learning activities. (Chen & Chen, 2021)	2.89	0.73	Aware
5. AI-based tools have made it easier for me to solve problems related to my flipped classroom coursework. (Wang, et al., 2019)	3.08	0.74	Aware
Composite Mean	3.00	0.62	Aware

Legend: 3.26 – 4.00 = Strongly Aware; 2.51-3.25 = Aware; 1.76-2.50 = Unaware; 1.00 – 1.75 = Strongly Unaware

AI-based problem-solving tools are recognized for their capacity to create customized adaptive learning experiences that assist students tackle complicated challenges (Heffernan & Heffernan, 2014; Woolf, 2010). This created help is especially important in STEM education, where the use of AI has been demonstrated to improve problem-solving efficiency and learning outcomes, notably in topics such as mathematics and engineering (Chen & Wang, 2016; Kumar & Rose, 2018). Students are better able to overcome hurdles and acquire stronger problem-

solving skills in these technical areas when they take use of AI's ability to provide real-time feedback and personalized learning routes.

Table 9. Chatbot Support

	$\underline{x}$	s	Interpretation
1. I use AI-powered chatbots to get immediate assistance with my flipped classroom questions. (Yang, et al., 2020)	2.54	0.81	Aware
2. AI chatbots provide timely and helpful responses to my queries about course material. (Kumpulainen & Lipponen, 2012)	2.98	0.72	Aware
3. I find AI-powered chatbots useful for receiving support outside of regular class hours. (Yang, et al., 2020)	2.88	0.84	Aware
4. The AI chatbots I use are effective in clarifying doubts and providing additional information. (Yang, et al., 2020)	2.92	0.78	Aware
5. I prefer using AI chatbots for instant help with course-related questions rather than waiting for in-class hours. (Kumpulainen & Lipponen, 2012)	2.58	0.95	Aware
Composite Mean	2.78	0.66	Aware

Legend: 3.26 – 4.00 = Strongly Aware; 2.51-3.25 = Aware; 1.76-2.50 = Unaware; 1.00 – 1.75 = Strongly Unaware

Table 9 reflects students' awareness of using AI as chatbot assistance in flipped classrooms with a composite mean of 2.78 and a standard deviation of 0.66. The use of AI-powered chatbots for receiving support outside regular class hours (x = 2.88) corresponds with Yang et al. (2020), who emphasized the growing use of chatbots for timely academic support. However, the moderate level of awareness indicates that while students recognize chatbots' potential, they may not yet fully trust or rely on them. Some students may feel more confident using chatbots, while others may prefer human interaction or feel uncertain about the reliability of AI-driven support.

This finding supports earlier research by Shum, He, and Li (2018), who emphasized that while chatbots can be effective tools for assisting students with immediate, on-demand help, trust in these systems must be cultivated through proper design and consistent performance. Furthermore, studies by McGookin, Morris, and O'Neill (2020) have shown that students are more likely to use AI-based tools when they perceive them as reliable and efficient in providing relevant academic support.

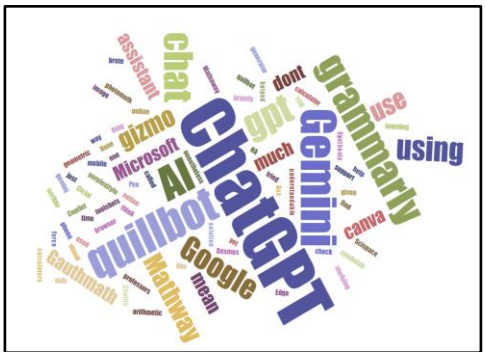

Figure 2. Artificial Intelligence Tools Used by College Students

Figure 2 illustrates the artificial intelligence tools that have been used by college students. The word cloud presented provides an insightful visualization of the most frequently used AI-based tools and applications. The central positioning and size of terms such as "ChatGPT," "Grammarly," "Quillbot," and "Gemini" suggest that these are among the most commonly referenced tools used by college students to support their learning. Brown et al. (2020)

highlighted that GPT-based models like ChatGPT have revolutionized how students interact with content, providing immediate feedback and support across disciplines.

CONCLUSION AND RECOMMENDATION

This study has explored college students' awareness and perceptions of the flipped classroom model, particularly its integration with artificial intelligence (AI) tools in mathematics education. The findings indicate that students acknowledge the significance of pre-class preparation, digital learning tools, and active participation, all of which are crucial for successful engagement in the flipped classroom model. Active involvement in class discussions and activities was associated with improvements in problem-solving skills, as well as enhanced study habits and time management, particularly in mathematics. While the flipped classroom model facilitated better comprehension and problem-solving abilities, there remains a need for additional support and refinement to optimize its effectiveness.

Furthermore, the study highlighted students' awareness of AI's potential to personalize learning, track progress, and provide immediate feedback. However, the use of AI-based tutoring systems and problem-solving tools was found to be limited, suggesting that further integration and alignment with classroom activities is necessary. AI chatbots, though recognized, were underutilized, revealing their untapped potential for offering academic support outside of regular class hours. Popular tools like ChatGPT, Grammarly, and Quillbot were frequently used, but students could benefit from increased awareness and training on specialized AI tools tailored to support subject-specific tasks.

Overall, the findings reveal an increasing understanding of AI's potential to improve the learning experience. To properly utilize these products, additional integration, training, and support are required. Future study should look into the efficacy of various AI tools in a variety of academic contexts, strategies for increasing AI use in flipped classrooms, and the long-term effects of AI on academic achievement and critical thinking skills.

Recommendations

First, flipped classrooms are widely recognized for their ability to increase engagement and participation. To retrieve these benefits, educators should continue to design activities that maximize student participation and encourage active learning within as well as outside the classroom. Despite the positive impact on engagement, research suggests that improvements in students' problem-solving skills are slightly less significant than other benefits. Therefore, educators should consider incorporating more complex, real-world problem-solving exercises to further develop students' analytical and critical thinking skills.

Although students recognize the prospective benefits of AI in improving learning, its full utilization remains limited. To close this gap, institutions should prioritize the integration of AI-based tutoring systems, problem-solving tools, and chatbots into flipped classrooms. In addition, training and awareness campaigns can help students better understand how to effectively use these technologies for personalized learning and instant feedback.

The moderate use of AI chatbots and tutoring systems suggests that students may need additional guidance to fully utilize these tools. To improve user's engagement, institutions should make these AI tools more intuitive and ensure seamless integration with existing learning platforms. This can promote their adoption and increase students' confidence in using AI for academic support outside of regular class time.

Finally, academic programs should promote the integration of AI across disciplines, including the arts, social sciences, and STEM. This approach will enable students to apply AI-based solutions to a wide range of tasks and projects, promote interdisciplinary learning, and enhance their technical capabilities in a rapidly evolving academic environment. By considering these recommendations, educational institutions can better support student learning, optimize the use of AI tools, and maximize the benefits of the interdisciplinary flipped classroom model.

Research Limitations and Future Directions

There are various restrictions on this study. First, only University of Makati college students were included in the sample, which limits how broadly the results can be applied. A more varied sample from different colleges and fields should be used in future studies. Second, because the study used data that students provided, biases might have been introduced because students' perspectives might not accurately reflect their actions or results. To supplement self-reports, future research could use more objective metrics, including academic success data. Finally, the study's exclusive focus on mathematics education limited the results' generalizability to other fields. To ascertain its wider efficacy, more research should examine the application of AI and flipped classrooms in other fields, such as the social sciences and humanities.

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