

AI-Supported Flipped Classroom in Teaching Business Mathematics: A Classroom Action Research

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Abstract:

Student learning outcomes in the Business and Economic Mathematics course at Universitas IBBI have shown a declining trend. Interviews revealed that lecturers with monodisciplinary backgrounds face difficulties in integrating mathematical models into economic and business contexts. To address these two interrelated problems, this study aims to improve student learning outcomes through the implementation of an AI-based flipped classroom. This study employed Classroom Action Research (CAR) involving 28 first-semester accounting students at Universitas IBBI. Data were collected through essay tests that had been tested for validity, reliability, item discrimination, and difficulty level. Subsequently, the data were analyzed using descriptive statistics. The implementation of an AI-based flipped classroom proved to improve student learning outcomes. The average score in Cycle I reached the success indicator, and increased further in Cycle II. In addition, students became more capable of solving non-linear equations and interpreting results in economic contexts. This improvement was attributed to guidance in formulating prompts, which enhanced student interaction with ChatGPT. The implementation of an AI-supported flipped classroom effectively improves student learning outcomes while bridging the interdisciplinary gap between mathematical concepts and economic applications. However, the effectiveness of this model depends on students' AI literacy and consistent access to the learning management system. Future research should employ quasi-experimental methods with larger samples and ensure adequate technical support.

Key Words: AI-Supported Flipped Classroom; Artificial Intelligence; Flipped Classroom; Learning Outcome

Introduction

Low learning outcomes in Business and Economic Mathematics represent a critical issue in higher education, as they not only affect students' academic achievement but also weaken their ability to make rational, data-based decisions in economic and business contexts. This condition can hinder students' readiness to take advanced courses that require strong quantitative skills, such as Economic Statistics, Microeconomics, and Econometrics, ultimately impacting their academic development and professional competence.

Based on a pre-survey conducted at Universitas IBBI, this problem was also identified among 28 accounting students. The data showed a declining trend in learning outcomes in Business and Economic Mathematics across three assessments. The average score decreased from 54 in the first assessment to 48 in the second

assessment, and further declined to 40 in the third assessment, all of which fell below the success indicator of 60, as presented in figure 01 below.

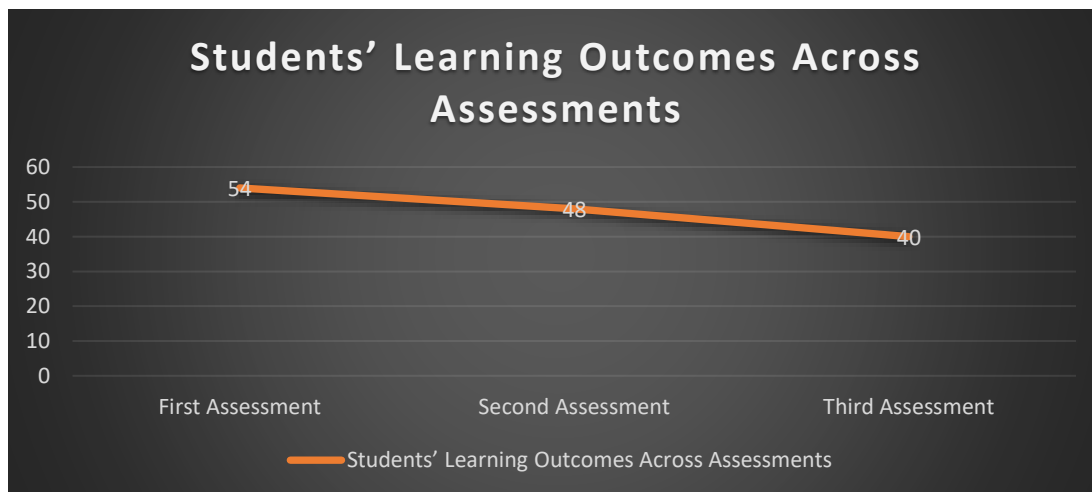


Figure 01

Declining Trend in Students' Learning Outcomes

To identify the causes of this issue, two lecturers were interviewed to explore the problems occurring in the field. The results of the brief interviews revealed that lecturers with a mathematics background experienced difficulties in contextualizing mathematical models into economic and business contexts. In contrast, lecturers with an economics background faced challenges in solving complex mathematical models. This imbalance led to suboptimal integration between mathematical and economic aspects, resulting in students' understanding not developing comprehensively.

To mitigate this problem, the flipped classroom is considered a potential approach to address the learning challenges described above. The flipped classroom is a learning design grounded in constructivist theory (Mustapha et al., 2020), which emphasizes the active role of students in constructing knowledge. In this model, students study the material independently before class, allowing face-to-face time to be focused on higher-order thinking activities, such as analysis, discussion, and problem-solving (Anggono et al., 2025).

However, the implementation of the flipped classroom alone has not been fully capable of accommodating the complexity of interdisciplinary learning (Pachaiyappan, 2024). In line with advances in educational technology, more adaptive technological support is required, including through the utilization of Artificial Intelligence (Carlo, 2025). ChatGPT, as an AI-based technology, has the potential to assist students not only in solving mathematical problems but also in interpreting the results within relevant economic and business contexts (Choustoulakis, 2024).

Furthermore, ChatGPT was selected based on the findings of a systematic literature review, which revealed that technology utilization in the flipped classroom model remains dominated by video-based media (29 studies) and Learning Management Systems (LMS) (7 studies), such as Moodle, Big Blue Button, and Mat Activa. Meanwhile, the use of AI-based technologies such as ChatGPT remains very limited (Baig & Yadegaridehkordi, 2023). This finding indicates a research gap in the integration of AI technology into the flipped classroom model, particularly in the context of Business and Economic Mathematics learning.

From a methodological perspective, most previous studies on the flipped classroom have employed quantitative approaches, with 32 studies applying experimental, evaluative, and survey methods. A total of 19 studies used mixed methods, while only one study employed a qualitative approach. This suggests that previous research has focused more on learning outcomes than on the learning process itself (Majid et al., 2024). Therefore, this study employs a Classroom Action Research (CAR) approach to examine the learning process while simultaneously improving students' learning outcomes in a sustainable manner.

Thus, this study offers new in three aspects. First, the integration of the flipped classroom with ChatGPT in the context of Business and Economic Mathematics. Second, the use of AI to overcome the limitations of lecturers with monodisciplinary backgrounds. Third, the application of the Classroom Action Research approach, which focuses on the learning process, in contrast to the majority of previous studies that were quantitative in nature, such as experimental, evaluative, and survey research.

Literature Review

The flipped classroom has been proven to improve learning outcomes, autonomy, and attitudes toward mathematics (Bolat & Biber, 2025; Ishartono et al., 2023; Lazzari, 2023). However, this model has a critical limitation during the independent learning phase outside the classroom: students do not receive real-time feedback when they encounter difficulties understanding interdisciplinary concepts in business and economic mathematics (Garzón et al., 2025; Pachaiyappan, 2024).

Artificial Intelligence (AI), including ChatGPT, addresses this gap by functioning as an intelligent tutoring system that provides concept explanations, instant feedback, and adaptive problem-solving support (Almassaad et al., 2024; Khairuddin et al., 2024). Furthermore, AI has been shown to enhance higher-order thinking skills (HOTS) and decision-making abilities (Sustaningrum & Haldaka, 2025; Yurt & Kasarci, 2024), which are essential demands of Business and Economic Mathematics courses.

By integrating AI into the flipped classroom, students receive virtual scaffolding during the self-directed learning phase. Consequently, face-to-face class time can be fully dedicated to HOTS activities such as analyzing demand and supply functions, determining market equilibrium points, and evaluating economic policies. This integration also overcomes the limitations of a single-discipline approach, as AI can explain cross-domain relationships between mathematical concepts and economic applications.

Despite these potential benefits, most studies still examine AI and the flipped classroom separately (Baig & Yadegaridehkordi, 2023). In fact, the integration of AI into the flipped classroom has the potential to support the improvement of learning outcomes in Business and Economic Mathematics by providing students with continuous cognitive support.

Nevertheless, the effectiveness of implementing this model requires empirical investigation while maintaining attention to academic ethics, particularly if assessments are conducted independent (Hanh & Duyen, 2025). Therefore, this study is needed to fill the existing literature gap, specifically through a classroom action research approach that focuses on the gradual improvement of the learning process.

Research Method

Research Design

This study adopts Classroom Action Research (CAR) to systematically improve learning quality through iterative cycles of planning, action, observation, and reflection conducted within an authentic classroom context (Coghlan & Shani, 2021). Classroom action research is appropriate for this study as it does not seek to test theoretical propositions, as in experimental designs, but rather to generate context-specific

improvements in instructional practice and learning outcomes (Sirror, 2025). Therefore, this approach is particularly relevant for practitioners seeking to implement and evaluate pedagogical innovations in real educational settings (Irwandi et al., 2019).

The research design follows a cyclical model comprising four stages: planning, action, observation, and reflection. This design enables the continuous refinement of instructional strategies based on empirical classroom evidence (Kemmis et al., 2020). In this study, the cycles are directed toward enhancing students' economic interpretation skills in the Business and Economic Mathematics course through the implementation of an AI-supported flipped classroom. This approach is expected to promote active learning, provide adaptive support, and strengthen students' conceptual understanding of economic problems.

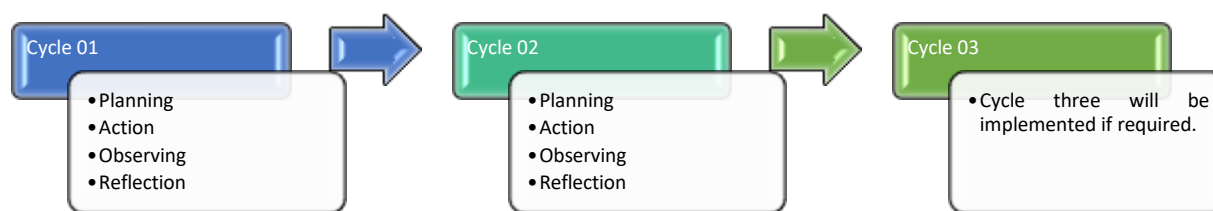


Figure 02

Action Research Cycles (Coghlan & Shani, 2021)

Research Procedure

Every study has its own unique procedures and characteristics, and this Classroom Action Research is no exception. This study was conducted through four stages: planning, action, observation, and reflection. In the planning stage, the researcher prepared the learning materials delivered via Google Classroom, designed the classroom learning syntax, developed examples of Business and Economic Mathematics cases, and prepared student evaluation instruments.

The action stage involved pre-class activities in which students accessed the provided learning resources. During in-class sessions, case discussions, in-depth analysis, and concept reinforcement were carried out. After class, students independently reviewed the material to consolidate their understanding.

In the observation stage, the researcher recorded learning activities and assessed student learning outcomes using the prepared instruments. The reflection stage was conducted to evaluate the effectiveness of the implemented actions and to formulate improvements for the next cycle. If the results in one cycle did not meet the success indicators, the study continued into the subsequent cycle.

Population and Sample

The research population consisted of 28 first-semester accounting students at Universitas IBBI enrolled in the Business and Economic Mathematics course. The sampling technique employed was a saturated sample, considering that the selected class possessed characteristics aligned with the research objectives, namely the need to strengthen students' economic interpretation skills in mathematical models.

Based on this technique, the sample comprised all 28 first-semester accounting students, who served as the research subjects.

Data Collection

Data were collected through a 10-item essay test in the form of case studies, designed to measure two aspects: the accuracy of mathematical problem-solving and the ability to interpret economic concepts. The test was divided into five items for Cycle I and five items for Cycle II. Prior to administration, the test items were analyzed using Anates version 4.0 to assess validity through the product-moment correlation, item discrimination, difficulty level, and reliability using Cronbach's Alpha coefficient. The instrument was pilot-tested on 20 respondents outside the research sample.

Operational Definition of Variables

This study involves two variables: a dependent variable and an independent variable. The dependent variable is the learning outcomes in Business and Economic Mathematics, measured through tests. The independent variable is the AI-supported flipped classroom.

Table 2. Operationalization of Research Variables

No	Variable	Operational Definition
1	Dependent	Learning outcomes in Business and Economic Mathematics refer to the level of students' cognitive mastery, measured through post-course tests. These outcomes include the ability to construct demand and supply equations, determine market equilibrium points, and analyze the relationship between price and quantity of goods in a market.
2	Independent	AI-Supported Flipped Classroom is a learning model that utilizes technologies such as Google Classroom and ChatGPT, enabling students to study the material prior to in-class sessions. Class time is subsequently dedicated to discussions, in-depth analysis, and problem-solving activities with AI support.

Data Analysis Technique

The data collected through the essay tests were analyzed using descriptive statistics, including the calculation of the mean, maximum, and minimum scores of the students in the class. Once the class average was obtained, it was compared to the predetermined success criterion, which was set at 60.

Result

Research Instrument Assessment

Prior to conducting the study, the initial stage involved testing the research instruments designed to measure students' learning outcomes in the Business and Economic Mathematics course. The instrument testing included validity analysis using the product-moment correlation, reliability assessment using Cronbach's Alpha, item difficulty level, and item discrimination. The results of the instrument testing are presented in the table below.

Table 3. Research Instrument Assessment Result

No	DP (%)	Difficulty	Reliability	Correlation	Significance of Correlation
1	42.00	Easy	0.96	0.896	Highly Significant

2	44.00	Medium	0.96	0.790	Highly Significant
3	42.00	Medium	0.96	0.795	Highly Significant
4	34.00	Hard	0.96	0.848	Highly Significant
5	36.00	Medium	0.96	0.803	Highly Significant
6	48.00	Medium	0.96	0.792	Highly Significant
7	34.00	Hard	0.96	0.811	Highly Significant
8	46.00	Medium	0.96	0.722	Highly Significant
9	50.00	Medium	0.96	0.783	Highly Significant
10	48.00	Easy	0.96	0.898	Highly Significant

Data Source: Anates Version 4.0

Based on the table above, the item discrimination test indicated that all items fell into the good category. The item difficulty was well-distributed, comprising two easy items, six medium items, and two hard items. The allocation of items was also planned according to the research cycles: items 1–5 was used in Cycle I, and items 6–10 were used in Cycle II.

The validity test using the product-moment correlation showed that all items had correlation coefficients above 0.700. Compared to the table value of $r = 0.444$ ($n = 20$), all items had R-values greater than r-table, indicating that all items were valid. Furthermore, the reliability test using Cronbach's Alpha formula yielded a coefficient of 0.96. This value falls into the very high category, indicating that the research instrument has excellent internal consistency. Therefore, the instrument was deemed suitable for use in the study.

Learning Outcomes Across Learning Cycles

The study began with the planning of the implementation of an AI-supported flipped classroom, followed by the execution of learning activities, observation, and reflection. The research was conducted in two cycles, with each cycle collecting data on students' learning outcomes in the Business and Economic Mathematics course, as presented in the table below.

Table 4. Students' Learning Outcomes Across Cycles

Cycle	Mean	Indicator	Maximum Score	Minimum Score
Cycle I	62	60	80	35
Cycle II	78	60	95	55

The table indicates an improvement in students' learning outcomes across the cycles. In Cycle I, the class average score was 62, exceeding the predetermined success criterion of 60. However, the minimum score of 35 suggests that some students had not yet achieved optimal mastery. In Cycle II, a notable improvement was observed, with the class average increasing to 78. The minimum score also rose to 55, indicating a better distribution of learning outcomes among students. Additionally, the maximum score increased from 80 to 95, reflecting overall improvement in student achievement. Compared to the three initial assessments (pre-cycle), the results of Cycle I and Cycle II demonstrated a consistent upward trajectory. Thus, students' learning outcomes in Business and Economic Mathematics improved from the third assessment to Cycle II, as presented in Figure 03 below.

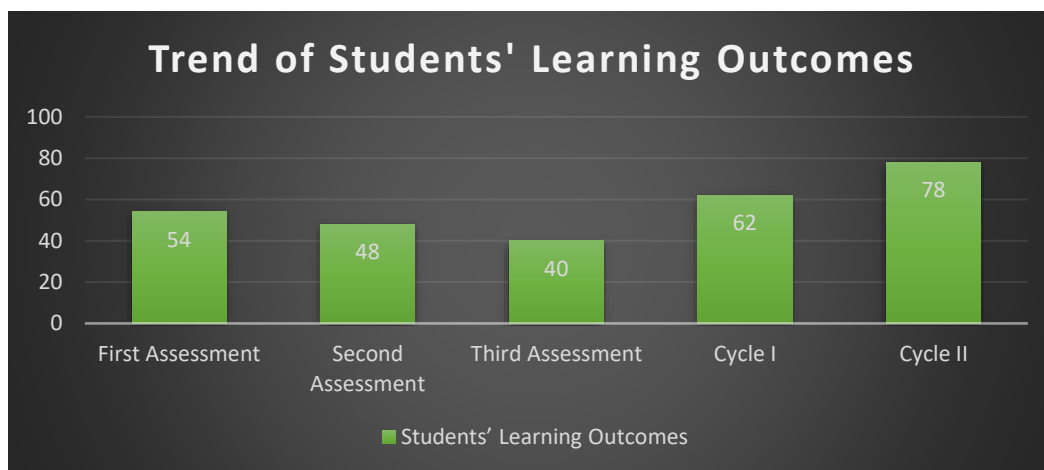


Figure 03

Learning Outcomes Trend from Assessments to Cycle II

Therefore, the AI-supported flipped classroom effectively drives positive trends in students' learning outcomes and bridges the interdisciplinary gap between mathematical concepts and their applications in economics and business.

Discussion

Research Question: To what extent does the implementation of an AI-supported flipped classroom improve students' learning outcomes?

The implementation of the AI-supported flipped classroom model in this study essentially follows the structure of the conventional flipped classroom, which consists of three stages: pre-class, in-class, and post-class (Bolat & Biber, 2025; Ishartono et al., 2023). However, in this study, the integration of Artificial Intelligence does not merely complement the instructional design; rather, it serves as a learning tool capable of overcoming the limitations of instructors with monodisciplinary backgrounds while also improving the quality of student learning. In the pre-class stage, students not only access materials through Google Classroom but also use AI to clarify their initial understanding in real time. In the in-class stage, AI acts as a cognitive verification tool, helping students validate mathematical procedures and strengthen their economic interpretations. Meanwhile, in the post-class stage, AI supports the process of reflection and independent reconstruction of understanding. This demonstrates that AI provides continuous scaffolding that bridges independent learning and guided learning.

From a constructivist perspective, the learning outcomes that met the success indicators as early as Cycle I reflect that students had actively engaged in the knowledge construction process before face-to-face instruction (Lazzari, 2023). Consequently, they entered the classroom with better cognitive readiness and were able to participate more meaningfully. However, the effectiveness of learning at this stage was not yet optimal. Students still experienced difficulties in solving nonlinear equations and interpreting the results in an economic context, mainly due to their limited ability to formulate appropriate prompts.

These findings indicate that the presence of AI alone does not automatically enhance learning quality; rather, it requires adequate interaction skills for the knowledge construction process to take place optimally.

In Cycle II, learning outcomes in mathematics for economics and business improved further. This was because the lecturer provided guidance on formulating effective prompts, enabling students to become more proficient in using ChatGPT to solve the cases assigned. Within the constructivist framework, this intervention served as scaffolding, allowing students to gradually develop independence (Choustoulakis, 2024). Moreover, the results of this study reveal a qualitative change in the learning process, in which students were able to collaborate more effectively, interpret mathematical models more accurately, and connect mathematical procedures with economic meaning more deeply (Galindo-Domínguez & Bezanilla, 2025). These findings suggest that AI not only functions as a problem-solving tool but also as a mediator of interdisciplinary learning, bridging understanding between mathematics and economics.

Compared to previous studies that generally used video-based flipped classrooms or Learning Management Systems (Anggono et al., 2025; Bolat & Biber, 2025; Egara & Mosimege, 2024; Lazzari, 2023), this research shows that AI integration through ChatGPT offers the advantage of real-time and adaptive feedback. Furthermore, this study uncovers an often-overlooked mechanism, namely, that the effectiveness of AI-assisted learning heavily depends on students' ability to formulate meaningful prompts. Thus, the success of this model is determined not merely by the use of technology, but by the combination of AI and user literacy, especially in the context of interdisciplinary learning.

On the other hand, this model also has limitations. The use of AI through ChatGPT requires adequate literacy so that students can generate accurate prompts, without it, the resulting interpretations may be flawed. Additionally, the success of the flipped classroom still depends on students' consistency in accessing the LMS, which serves as the foundation for in-class learning.

Another significant challenge is the risk of cognitive dependency on AI, where the ease of obtaining instant answers may reduce students' efforts to engage in deep thinking (Garzón et al., 2025; Hanh & Duyen, 2025). Therefore, within the constructivist framework, AI must be positioned as a mediator of learning, not as a substitute for critical thinking processes, so that students remain active in building understanding independently.

Conclusion

This study concludes that implementing an AI-supported flipped classroom improves learning outcomes in Business and Economic Mathematics for early-semester students. The class average increased from 62 in Cycle I to 78 in Cycle II, exceeding the success indicator of 60. Theoretically, this research contributes to constructivist-based learning by integrating the flipped classroom with ChatGPT in Business and Economic Mathematics instruction. It fills a literature gap, as previous studies focused mainly on video-based media and LMS, with limited attention to AI. Practically, the findings help instructors, especially those with monodisciplinary backgrounds, develop teaching strategies for interdisciplinary courses. For students, this model enhances their ability to interpret mathematical concepts in economic and business contexts. Future researchers should increase sample size, extend research duration, use quasi-experimental methods, and ensure adequate facilities. Practitioners must position AI as a learning mediator, not a substitute for critical thinking, to prevent cognitive dependency.

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