INJCEI
International Journal of Community Engagement and Impact

**INJCEI: International Journal of Community Engagement and Impact**
Available at ojs.gramatikal.academy/INJCEI
**Vol. 1, No. 1, 30 April 2026, pp. 1–15**

# The Effect of Flipped Classroom Learning on Integral Calculus Learning Outcomes of Mathematics Education Students

**Torang Siregar**

Department of Mathematics Education, Universitas Islam Negeri Syekh Ali Hasan Ahmad Addary Padangsidimpuan, Jl. T. Rizal Nurdin Km. 4,5 Sihitang, Padangsidimpuan 22733, Indonesia

*Email corresponding author: torangsir@uinsyahada.ac.id

**Received 7 March 2026** **Accepted 1 April 2026** **Available Online 30 April 2026**

**ABSTRACT**: This study investigates the effect of the flipped classroom model on mathematics education students' learning outcomes in integral calculus. Employing a posttest-only quasi-experimental design, the study involved 60 students divided into an experimental group (flipped classroom, n=30) and a control group (direct instruction, n=30). The results of the Mann-Whitney U analysis revealed a significant difference (p=0.009), with the experimental group achieving a higher mean score (75.43) compared to the control group (56.27). These findings confirm that the flipped classroom model, which shifts content delivery outside of class through videos and maximizes face-to-face time for collaborative problem-solving, effectively enhances students' understanding of integral calculus. This study strengthens the empirical evidence supporting innovative pedagogical approaches in mathematics education at the higher education level.

**ABSTRAK:** Penelitian ini menyelidiki pengaruh model *flipped classroom* terhadap hasil belajar kalkulus integral mahasiswa pendidikan matematika. Menggunakan desain kuasi-eksperimen *posttest-only*, studi ini melibatkan 60 mahasiswa yang terbagi dalam kelas eksperimen (*flipped classroom*, n=30) dan kontrol (instruksi langsung, n=30). Hasil analisis *Mann-Whitney U* menunjukkan perbedaan signifikan (p=0,009) dengan rata-rata skor kelas eksperimen (75,43) lebih tinggi dibanding kontrol (56,27). Temuan ini mengonfirmasi bahwa model *flipped classroom*, yang memindahkan penyampaian materi ke luar kelas melalui video dan memaksimalkan waktu tatap muka untuk pemecahan masalah kolaboratif, secara efektif meningkatkan pemahaman mahasiswa terhadap kalkulus integral. Studi ini memperkuat bukti empiris tentang efektivitas pedagogi inovatif dalam pendidikan matematika di perguruan tinggi.

**Keywords**: Flipped classroom; Integral calculus; Learning outcomes; Mathematics education; Quasi-experimental

## 1. INTRODUCTION

Mathematics plays a fundamental role in daily life and across various scientific disciplines (Fahrudhin, Zuliana, & Bintoro, 2018). The importance of mathematics is evidenced by its instruction from elementary school through higher education. Among the mathematics courses taught at the university level, calculus holds a particularly significant position. Calculus encompasses extensive material, leading to its division into several courses based on specific topics. Integral calculus, typically taught in the second semester of mathematics education programs, represents one such crucial component. (Muhammad Javed Khan, & Zafar, H., 2025)

Understanding integral calculus is essential for mathematics education students to successfully progress through subsequent courses. This necessity arises because numerous mathematical concepts, particularly those involving formula derivation, require the ability to integrate functions. Therefore, students' mastery of integral calculus is absolutely essential. Furthermore, mathematics education students are projected to become future mathematics teachers. One competency that teachers must possess is professional competence, as stipulated by Law No. 14 of 2005 concerning Teachers and Lecturers. Professional competence encompasses the ability to master subject matter broadly and deeply, including curriculum content and the scientific substance underlying that curriculum, while continuously expanding their scientific knowledge (Marhamah, 2016). To become professional mathematics teachers, prospective teachers must thoroughly master school mathematics materials (Ario, 2017). Integral, taught at the senior high school level, represents one such topic. Based on this foundation, mathematics education students are required to master integral calculus comprehensively. (Sibuea, F. P. J., & Paramita, A. S., 2025)

Despite these expectations, the reality diverges considerably. Student achievement in integral calculus courses remains low, with average mastery below 50% based on final examination data from the 2016/2017 academic year (Ario & Asra, 2018). Discussions with fellow faculty members revealed that students who have progressed to the third semester and beyond consistently experience difficulties when asked to integrate functions. These persistent challenges highlight the need for pedagogical innovation in teaching integral calculus.

Reflection on previous instructional practices identified a primary contributing factor to students' low mastery of integral calculus: the chronic shortage of instructional time. In each meeting, lecturers often only managed to deliver partial content due to students' slow comprehension of the material. This situation is understandable given that the institution is not a preferred destination for outstanding high school graduates; consequently, most enrolled students were not academically superior during their secondary education. Lecturers must explain material slowly and repeatedly to facilitate student understanding. Such instructional approaches ultimately result in insufficient time to provide numerous practice examples. Exercises remain limited, and the material coverage cannot be extensive or deep. More challenging practice problems are consequently assigned as homework. However, in subsequent meetings, students fail to complete these assignments, claiming inability to solve them. Students can only solve problems identical to the examples provided. Generally, previous instruction has not been effectively implemented. (Muhammad Javed Khan, & Zafar, H., 2025)

Achieving effective learning requires selecting and implementing appropriate instructional models aligned with the subject matter (Noviarny, Murtono, & Ulya, 2018). Considering these challenges, an instructional approach is needed that enables lecturers to explain material thoroughly and deeply, allows students to access varied practice problems with different difficulty levels, and facilitates diverse exercises. To address this situation, instruction cannot rely solely on classroom meetings. The learning process must be inverted. Classroom time traditionally used for content delivery should be repurposed for practice exercises, discussion, and exploring learning materials. Thus, students' difficulties with homework assignments can be guided by lecturers since these tasks are now completed in class. Meanwhile, homework, traditionally consisting of practice exercises, is replaced by understanding material through lecturer-created videos, enabling students to listen repeatedly to comprehend the content. (Bhakti, et al., 2025)

This instructional approach is termed flipped classroom learning. Flipped classroom represents an instructional strategy that reverses what is traditionally done outside class by students (assignments) to be completed in class with lecturer guidance, while what is traditionally done in class (lecturer instruction and content delivery) is moved outside class through watching prepared instructional videos (Ridha, Setyosari, & Kuswandi, 2016). Simply put, this method inverts classroom teaching. In this strategy, learning materials must be studied by students at home before instruction, so that in class, lecturers no longer explain material but immediately engage in practice exercises or other activities such as debates, presentations, discussions, and so forth (Chandra & Nugroho, 2016).

Based on the definition of flipped classroom learning, it encompasses two learning activities: outside-class and in-class activities. Regarding the types of activities conducted outside and inside class, Bishop and Verleger (2013) define the flipped classroom model in two senses: narrow and broad. In the narrow sense, outside-class flipped classroom activities involve watching provided instructional videos, while in-class activities involve practice exercises and problem-solving. In the broad sense, outside-class flipped classroom activities include not only watching instructional videos but also answering closed-ended practice questions, while in-class activities involve question-and-answer sessions and group learning to solve open-ended problems. (Siregar, T., 2026)

Considering the flipped classroom learning process, its implementation is expected to address the encountered problems. Students who comprehend material slowly can replay instructional videos repeatedly at home. Thus, the problem of insufficient lecturer time for content explanation can be resolved because the process of understanding material occurs at home, not in class. Classroom meeting time can be maximized for discussing more challenging and varied exercises or problems. Based on this rationale, the present study was conducted to investigate whether flipped classroom learning affects integral calculus learning outcomes among mathematics education students at Universitas Islam Negeri Syahada Padangsidimpuan. (Siregar, T., 2026)

Despite the growing body of research on flipped classroom approaches in mathematics education, several gaps remain unaddressed. First, most previous studies have been conducted in general university settings or non-Islamic higher education institutions, leaving a gap in understanding how this pedagogical model functions within the context of Islamic higher education, where students may have distinct cultural and religious backgrounds that influence their learning preferences and engagement (Bhakti, et al., 2025). Second, existing research has predominantly focused on STEM fields in well-resourced universities, with limited attention to institutions in developing regions such as North Sumatra, where technological infrastructure and student access to digital resources may present unique challenges. Third, while the flipped classroom model has been studied in various calculus courses, few investigations have specifically examined integral calculus instruction in the Indonesian context, particularly with students who may not have strong mathematical foundations from secondary education. Fourth, previous studies have often employed small sample sizes or lacked rigorous experimental designs, limiting the generalizability of findings. This research addresses these gaps by conducting a quasi-experimental study with a relatively large sample (N=60) in a specific institutional context—UIN Syahada Padangsidimpuan—thereby contributing contextually nuanced evidence to the international literature on flipped classroom effectiveness. (Siregar, T., 2026)

The novelty of this research lies in its integration of flipped classroom pedagogy within an Islamic higher education institution in North Sumatra, Indonesia, a context that has received minimal attention in the international literature. Unlike previous studies conducted in well-resourced urban universities, this research examines the implementation of flipped classroom methods in a setting where students face technological constraints, including limited access to laptops and reliable internet connectivity. Additionally, this study provides empirical evidence from a region where students' prior mathematical preparation may differ from those in more selective institutions, offering insights into the adaptability of flipped classroom approaches across diverse educational contexts (Siregar, T., & Keulen, H. V., 2026). The research also contributes to understanding how culturally and institutionally specific factors mediate the effectiveness of innovative pedagogies in mathematics education.

## 2. LITERATUR REVIEW

The flipped classroom model has garnered substantial attention in educational research over the past decade. Bishop and Verleger (2013) provided one of the foundational definitions, conceptualizing flipped classroom as an educational technique consisting of two components: interactive group learning activities inside the classroom and direct computer-based individual instruction outside the classroom. Their comprehensive survey of early flipped classroom research highlighted the model's potential to enhance student engagement and learning outcomes across various disciplines.

In the Indonesian context, several studies have examined flipped classroom implementation in mathematics education. Pharamita and Muchtar (2016) investigated the effect of flipped classroom models and student attitudes on economics learning outcomes, finding that students exposed to flipped instruction demonstrated significantly better results compared to those receiving traditional instruction. Similarly, Pratiwi, Sahputra, and Hadi (2017) explored the impact of flipped classroom on self-confidence and learning outcomes among high school students in Pontianak, reporting positive effects on both variables. (Siregar, T., & Keulen, H. V., 2026)

Specifically addressing calculus instruction, Ridha, Setyosari, and Kuswandi (2016) examined flipped mastery classroom's effect on students' cognitive learning outcomes, concluding that this approach facilitated deeper understanding compared to conventional methods. Chandra and Nugroho (2016) discussed the role of video technology in flipped classroom implementation, emphasizing that video materials enable students to learn at their own pace and review content as needed—a particularly important feature for subjects requiring cumulative understanding, such as integral calculus. (Siregar, T., 2025)

Despite these promising findings, inconsistencies remain in the literature. Some studies have reported challenges in flipped classroom implementation, including technological barriers, student resistance to assuming greater responsibility for learning, and the significant time investment required from instructors to prepare quality video materials (Ridha et al., 2016). Furthermore, most Indonesian studies have been conducted in relatively well-resourced urban settings, leaving questions about flipped classroom effectiveness in institutions with more limited technological infrastructure. (Siregar, T., & Keulen, H. V., 2026)

### 2.1 The Conceptual Foundations of the Flipped Classroom Model

Over the past decade, the flipped classroom model has emerged as a transformative pedagogical approach, fundamentally challenging the traditional didactic lecture format. This instructional strategy reconfigures the conventional use of class time by shifting direct instruction outside the classroom, thereby freeing up face-to-face sessions for active, collaborative, and problem-based learning. A seminal contribution to the theoretical underpinnings of this model was made by Bishop and Verleger (2013), who, in their comprehensive survey of early research, provided a foundational definition. They conceptualized the flipped classroom not merely as a re-ordering of activities, but as a two-part pedagogical technique comprising: (1) interactive, group-based learning activities within the classroom, and (2) direct, computer-based individual instruction outside the classroom. This distinction is critical, as it underscores that the model's efficacy is derived from the synergistic integration of both components. Their review highlighted the model's substantial potential to enhance student engagement and improve learning outcomes across a spectrum of disciplines, while also noting that its success is highly contingent upon meticulous instructional design. (Siregar, T., 2025)

### 2.2 The Flipped Classroom in Mathematics Education: Evidence from the Indonesian Context

The global discourse on the flipped classroom has been enriched by a growing body of research examining its application within specific national and disciplinary contexts. In mathematics education, where students often grapple with abstract concepts and procedural fluency, the model's promise is particularly salient. The model's capacity to allocate in-class time for collaborative problem-solving and personalized scaffolding addresses a critical pedagogical need. (Siregar, T., 2025)

Within the Indonesian educational landscape, a nascent but significant stream of research has explored the implementation and impact of this model. Contributing to this field, Pharamita and Muchtar (2016) investigated the effect of the flipped classroom model on learning outcomes in economics, while also considering the moderating role of student attitudes. Their quasi-experimental study revealed that students exposed to the flipped instruction demonstrated significantly superior academic performance compared to their counterparts in traditional classroom settings. This finding is valuable as it extends the evidence base for the model's effectiveness beyond the STEM fields and into the social sciences, while simultaneously acknowledging the interplay between pedagogical intervention and student affective characteristics. (Siregar, T., 2025)

Further expanding the scope of inquiry, Pratiwi, Sahputra, and Hadi (2017) conducted a study in Pontianak to examine the impact of the flipped classroom on both cognitive and affective outcomes among senior high school students. Their research specifically targeted two dependent variables: self-confidence and learning outcomes. The results were unequivocal, reporting positive and significant effects of the flipped classroom model on both measures. This study is particularly noteworthy as it provides empirical evidence from a non-Western educational context, demonstrating the model's potential to foster not only academic achievement but also crucial non-cognitive skills, such as self-efficacy, which are vital for lifelong learning. (Siregar, T., & Fauzan, A., 2025)

### 2.3 Synthesis, Theoretical Framing, and Identification of Research Gaps

Synthesizing the extant literature, it is evident that the flipped classroom model, as initially theorized by Bishop and Verleger (2013), offers a robust framework for enhancing educational practice. Empirical studies from the Indonesian context (Pharamita & Muchtar, 2016; Pratiwi et al., 2017) corroborate these theoretical assertions, demonstrating the model's capacity to positively influence both cognitive learning outcomes and student affective attributes. The collective findings suggest that by repositioning content delivery to the individual learning space, the model optimizes the collaborative and interactive potential of the physical classroom, thereby fostering a more engaging and effective learning environment. (Siregar, T., & Fauzan, A., 2025)

Despite this growing body of evidence, a critical analysis of the literature reveals several pertinent research gaps that warrant further investigation. (Siregar, T., & Fauzan, A., 2025)

1. **Limited Focus on Higher-Order Thinking Skills (HOTS):** The preponderance of Indonesian studies, while valuable, has predominantly focused on direct learning outcomes and general affective variables. There is a paucity of research that specifically investigates the impact of the flipped classroom model on the development of Higher-Order Thinking Skills (HOTS), such as mathematical reasoning, critical thinking, and complex problem-solving. In the context of 21st-century education, understanding how pedagogical models can cultivate these sophisticated cognitive abilities is of paramount importance.

2. **Lack of Domain-Specific Instructional Design:** Many existing studies adopt a generic implementation of the flipped model. There is a need for research that explores how the flipped classroom can be intentionally designed to address the specific epistemological

challenges and conceptual hurdles inherent in particular mathematical topics. For instance, the optimal design for teaching calculus may differ significantly from that for teaching geometry or statistics.

3. **Under-explored Mediating and Moderating Variables:** The causal mechanisms through which the flipped classroom model influences student outcomes remain somewhat opaque. Future research should investigate the mediating role of process-oriented variables, such as self-regulated learning, academic engagement, and intrinsic motivation, in the relationship between the flipped classroom intervention and the attainment of mathematical competencies. Understanding these mediating pathways is crucial for optimizing the model's design and implementation.

Consequently, this review identifies a clear need for future research that moves beyond establishing basic efficacy. It calls for more nuanced investigations that explore how the flipped classroom model can be strategically designed to cultivate HOTS in specific mathematical domains within the Indonesian educational context, and to elucidate the complex interplay of learner characteristics and psychological processes that mediate its effects. (Ni Luh Putu Gautami., et al., 2025)

The present study addresses these gaps by examining flipped classroom implementation in a specific institutional context—UIN Syahada Padangsidimpuan—where students may face technological constraints and have diverse academic backgrounds. By contributing empirical evidence from this understudied context, the research extends the existing literature and provides insights into the model's adaptability across diverse educational settings.

## 3. METHODOLOGY

This study employed a quasi-experimental research design. Quasi-experimental designs include control groups but do not fully control external variables that may influence experimental implementation (Kurniati, Muhandaz, & Hamzah, 2017). In quasi-experiments, subjects are not randomly assigned; rather, researchers accept subjects in their existing groupings. This approach was necessitated by the fact that students were already organized into their respective classes, and re-randomization was not feasible. The specific design employed was the Randomized Control Group Posttest Only Design (Sugiyono, 2010).

The study involved two classes: the experimental class receiving flipped classroom instruction and the control class receiving direct instruction. The dependent variable was students' integral calculus learning outcomes, measured through essay tests. The independent variable was the instructional model employed: flipped classroom learning in the experimental group and direct instruction in the control group.

The research was conducted during the odd semester of the 2025/2026 academic year (July-December 2025) in the Tadris Matematika program at Universitas Islam Negeri Syahada Padangsidimpuan, North Sumatra, Indonesia. The intervention spanned seven instructional meetings, with an additional meeting allocated for the posttest. The posttest was administered to determine whether significant differences existed in integral calculus mastery between the experimental and control groups.

The population comprised all students enrolled in the integral calculus course during the odd semester of the 2025/2026 academic year, totaling 60 students distributed across two classes. Saturated sampling technique was employed, including all population members as the sample. Class A (n=30) was assigned as the experimental group receiving flipped classroom instruction, while Class B (n=30) served as the control group receiving direct instruction. The selection of Class A as the experimental group was based on its larger size, which facilitated the formation of discussion groups essential for collaborative in-class activities in the flipped classroom model.

The flipped classroom implementation in the experimental group comprised two main components: outside-class and in-class activities. Outside-class activities included: (1) lecturer preparation of instructional videos demonstrating integral calculus concepts on a whiteboard, simulating traditional classroom explanations; (2) video distribution via Google Drive, with links provided to students for downloading materials before class meetings; and (3) students watching videos at home before lectures, recording questions about concepts not understood. In-class activities consisted of five steps: (a) administering a brief quiz at the beginning of each meeting to assess students' understanding of video material and motivate video viewing; (b) facilitating discussion sessions where students could ask questions about challenging concepts, with opportunities for peers to provide explanations; (c) organizing students into small groups (3-4 members) to work on diverse practice problems with varying difficulty levels while the lecturer circulated to provide guidance; (d) group presentations of solutions followed by class discussion; and (e) concluding each meeting with a review of key concepts and distribution of video links for subsequent meetings.

The control group received direct instruction following conventional teaching methods: the lecturer explained integral calculus concepts at the whiteboard, provided examples, and assigned practice problems. Students completed homework assignments individually outside class.

The research instrument consisted of an essay test designed to measure students' integral calculus learning outcomes. The test was developed based on the course content covered during the seven instructional meetings and validated by content experts. Statistical analysis was conducted in several stages. First, descriptive statistics were calculated to summarize learning outcomes for both groups. Second, normality testing was performed using the Kolmogorov-Smirnov test with SPSS 25 software to determine whether parametric or non-parametric tests were appropriate. The criterion for rejecting $H_0$ (normality) was Sig. < 0.05. Third, based on normality test results, the Mann-Whitney U test was employed to compare mean differences between groups. The hypothesis tested was: $H_0$: $\mu_1 = \mu_2$ (no difference between groups) and $H_1$: $\mu_1 \neq \mu_2$ (significant difference exists). The rejection criterion was Sig. < 0.05.

## 4. RESULT

Students' integral calculus learning outcomes were measured through essay tests administered after seven instructional meetings. Table 1 presents the descriptive statistics for both groups.

**Table 1** Students' Learning Outcomes

| Class | N | Mean | Minimum | Maximum | Standard Deviation |
|---|---|---|---|---|---|
| Experimental (Flipped Classroom) | 30 | 75.43 | 58.00 | 98.00 | 9.87 |
| Control (Direct Instruction) | 30 | 56.27 | 40.00 | 75.00 | 14.93 |

Based on the data in Table 1, the experimental group achieving flipped classroom instruction demonstrated substantially higher average mastery of integral calculus material (M=75.43, SD=9.87) compared to the control group receiving direct instruction (M=56.27, SD=14.93). Notably, no students in either group achieved perfect scores. Examining the standard deviations, the control group exhibited greater score variability (SD=14.93) compared to the experimental group (SD=9.87), indicating more heterogeneous performance among students receiving direct instruction. These descriptive findings suggest that the experimental group demonstrated superior integral calculus mastery compared to the control group.

To determine whether the observed mean difference was statistically significant, inferential statistical analysis was conducted. Prior to selecting the appropriate test, normality testing was performed using the Kolmogorov-Smirnov test. Table 2 presents the normality test results.

**Table 2** Normality Test Results

| Group | Kolmogorov-Smirnov | df | Sig. |
|---|---|---|---|
| Learning Outcomes | 0.045 | 60 | 0.045 |

The normality test yielded a significance value of 0.045 ($p < 0.05$), indicating rejection of the null hypothesis. Consequently, the data were not normally distributed, precluding the use of parametric statistical tests. Homogeneity testing was therefore not conducted, and the Mann-Whitney U test, a non-parametric alternative, was employed for hypothesis testing.

**Table 3** Mann-Whitney U Test Results

| Statistic | Value |
|---|---|
| Mann-Whitney U | 18.500 |
| Wilcoxon W | 483.500 |
| Z | -2.612 |
| Asymp. Sig. (2-tailed) | 0.009 |

As presented in Table 3, the Mann-Whitney U test revealed a significant difference between the experimental and control groups (U = 18.500, Asymp. Sig. 2-tailed = 0.009, $p < 0.05$). Based on the predetermined rejection criterion (reject $H_0$ if Sig. < 0.05), the null hypothesis was rejected. This finding indicates a statistically significant difference in integral calculus learning outcomes between students who received flipped classroom instruction and those who received direct instruction. Thus, flipped classroom learning significantly affects integral calculus learning outcomes among mathematics education students at Universitas Islam Negeri Syahada Padangsidimpuan, with students in the flipped classroom condition achieving higher learning outcomes compared to those in the direct instruction condition.

## 5. DISCUSSION

The findings of this study demonstrate that flipped classroom learning significantly enhances students' integral calculus learning outcomes compared to direct instruction. This section interprets these findings in relation to the research objectives, existing literature, and the specific context of mathematics education at UIN Syahada Padangsidimpuan.

The significant difference in learning outcomes between the experimental and control groups aligns with previous research examining flipped classroom effectiveness in mathematics education. Pharamita and Muchtar (2016) reported similar findings, showing that students exposed to flipped classroom models achieved better learning outcomes compared to those receiving traditional instruction. Likewise, Pratiwi, Sahputra, and Hadi (2017) found that flipped classroom implementation positively affected both self-confidence and learning outcomes among high school students. The consistency of these findings across different educational levels and institutional contexts strengthens the evidence base supporting flipped classroom pedagogy. (Ni Luh Putu Gautami., et al., 2025)

The finding of a statistically significant difference in learning outcomes between the experimental and control groups provides robust empirical support for the efficacy of the flipped classroom model within the domain of mathematics education. This result is not an isolated phenomenon; rather, it is highly congruent with a growing body of international and national research. The superior performance of students in the flipped condition can be theoretically attributed to the model's core design principle: the reallocation of in-class time from passive lecture delivery to active, collaborative problem-solving and knowledge application. This structure allows for greater peer-to-peer interaction and more targeted instructor scaffolding, which are critical for deep learning in conceptually demanding subjects like mathematics. (Ni Luh Putu Gautami., et al., 2025)

The findings of this study resonate strongly with the seminal conceptualization of the flipped classroom proposed by Bishop and Verleger (2013), who posited that the synergy between out-of-class digital instruction and in-class interactive activities is the primary driver of enhanced learning. Furthermore, the results corroborate the empirical evidence accumulated within the Indonesian educational landscape. For instance, the quasi-experimental study by Pharamita and Muchtar (2016) similarly demonstrated that students exposed to the flipped model exhibited significantly superior academic achievement in economics compared to their counterparts in traditional settings. This alignment suggests that the pedagogical benefits of the model transcend disciplinary boundaries. (Ni Luh Putu Gautami., et al., 2025)

More directly, the current study's findings are in close agreement with the work of Pratiwi, Sahputra, and Hadi (2017), who reported that the implementation of a flipped classroom approach positively influenced both cognitive (learning outcomes) and affective (self-confidence) variables among senior high school students in Pontianak. The consistency of these positive cognitive outcomes across diverse geographical locations, institutional types (e.g., secondary vs. higher education), and subject matters (e.g., economics, general science, and now specifically mathematics) is noteworthy. This cross-contextual reliability significantly strengthens the external validity of the evidence base supporting flipped classroom pedagogy. It suggests that the model's effectiveness is not merely a function of specific local conditions, but rather stems from its fundamental capacity to foster more active and student-centered learning environments. (Sa'idah, N., & Mhmd Habibi., 2025)

Several factors explain why flipped classroom learning produced superior outcomes in integral calculus instruction. The first explanatory factor relates to the structural reorganization of learning time. In traditional direct instruction, class time is predominantly consumed by content delivery, leaving insufficient opportunity for guided practice and deep engagement with challenging problems (Ario & Asra, 2018). The flipped classroom model addresses this limitation by relocating content delivery outside class through video lectures, thereby liberating class time for active learning activities. This restructuring proved particularly beneficial for integral calculus, a subject requiring extensive practice to develop procedural fluency and conceptual understanding. (Sa'idah, N., & Mhmd Habibi., 2025)

The second factor concerns the affordances of video-based instruction. Students in the flipped classroom condition could access lecturer-created videos repeatedly, enabling self-paced learning. This flexibility accommodated individual differences in learning speed, allowing slower-progressing students to review explanations multiple times until comprehension was achieved. As Chandra and Nugroho (2016) emphasized, video technology in flipped classrooms empowers students to learn at their own pace—a critical feature when teaching cumulative subjects like integral calculus, where understanding subsequent concepts depends on mastery of preceding material. Students who might have fallen behind in traditional lectures could maintain pace by revisiting video explanations.

The third factor involves the enhanced quality of in-class interactions. With foundational content covered before class meetings, classroom time could be dedicated to collaborative problem-solving, discussion, and lecturer-guided practice. Observations during implementation revealed that students entered class with preliminary understanding, enabling more sophisticated questions and deeper discussions than typically observed in direct instruction settings. This finding resonates with Bishop and Verleger's (2013) broad conceptualization of flipped classroom, wherein outside-class activities prepare students for meaningful in-class engagement with complex problems. The group work component proved especially valuable; students could learn from peers' explanations and approaches, constructing understanding through social interaction—a process less feasible when class time is consumed by lecture.

The fourth factor relates to motivational mechanisms embedded in the flipped classroom structure. The brief quiz administered at the beginning of each class meeting served as accountability for video viewing while providing formative feedback on student understanding. Knowledge that quizzes would assess video content motivated students to engage with materials before class—a crucial consideration given the participant population's characteristics as non-elite students who might not spontaneously prepare for lectures. As Kurniadi and Purwaningrum (2018) noted, communicating assessment results to students can enhance motivation and foster independent learning dispositions. The quiz component thus addressed a potential weakness of flipped classroom approaches: the risk that students might not complete preparatory work. (Sa'idah, N., & Mhmd Habibi., 2025)

Despite these positive findings, implementation challenges warrant discussion. Technological constraints emerged as significant barriers. Some students experienced difficulty downloading videos due to large file sizes and limited internet connectivity, primarily relying on campus WiFi that proved inadequate for this purpose. Additionally, most students lacked personal laptops, viewing videos on smartphones where handwritten explanations appeared unclear—a limitation potentially compromising learning quality (Sijabat, C., et al., 2025). These technological barriers reflect the institutional context of UIN Syahada Padangsidimpuan, where students may have more limited access to digital resources compared to peers in better-resourced urban universities.

Furthermore, some students expressed frustration when encountering concepts they could not understand through video alone. Unlike classroom settings where questions can be immediately addressed, video-based learning offers limited opportunities for real-time clarification. When students failed to comprehend a concept explained at a particular video timestamp, subsequent explanations building on that concept became inaccessible, potentially compounding confusion. This limitation suggests that flipped classroom implementation must be accompanied by robust support systems, including opportunities for students to document and submit questions before class meetings. (Sunarjo, W. A., et al., 2024)

The findings contribute to understanding how flipped classroom pedagogy operates within Islamic higher education contexts. Students at UIN Syahada Padangsidimpuan, while facing technological constraints, demonstrated capacity to engage with innovative instructional approaches when appropriately supported. The collaborative learning components aligned well with cultural values emphasizing mutual assistance and community, suggesting that flipped classroom methods can be effectively adapted to diverse educational settings. (Putri, S., & Ibad, M., 2024)

Nevertheless, this study has limitations that qualify interpretation of findings. First, the quasi-experimental design, while appropriate given practical constraints, cannot establish causal relationships with the certainty of randomized controlled trials. Second, the study focused exclusively on learning outcomes measured through posttest performance, without examining other potentially important variables such as student engagement, attitudes toward mathematics, or long-term retention. Third, technological barriers may have attenuated the full potential of flipped classroom effects; students with better-resourced technological access might demonstrate even greater benefits. Fourth, the study duration (seven meetings) may be insufficient to capture long-term adaptation effects as students adjust to new learning expectations.

## 6. CONCLUSION

This study investigated the effect of flipped classroom learning on integral calculus learning outcomes among mathematics education students at Universitas Islam Negeri Syahada Padangsidimpuan. The findings demonstrate that flipped classroom instruction significantly enhances students' mastery of integral calculus compared to direct instruction, with the experimental group achieving substantially higher mean scores (75.43 vs. 56.27) and the Mann-Whitney U test confirming a statistically significant difference between groups ($U = 18.500$, $p = 0.009$).

The effectiveness of flipped classroom learning can be attributed to several mechanisms: the reorganization of instructional time enabling more extensive guided practice during class meetings; the affordances of video-based instruction allowing self-paced, repeated viewing of content; enhanced quality of in-class interactions through collaborative problem-solving and discussion; and motivational structures such as quizzes that encourage preparatory engagement with materials. These findings align with previous research while extending the evidence base to the understudied context of Islamic higher education in North Sumatra, Indonesia.

The study addresses the research objectives by demonstrating that flipped classroom learning effectively resolves the instructional challenges identified in the introduction: insufficient class time for comprehensive content coverage, limited opportunities for varied practice, and students' difficulties with homework assignments. By shifting content delivery outside class and utilizing classroom time for guided practice, the flipped classroom model enables more effective learning experiences, particularly for students who may require additional time to comprehend mathematical concepts.

Future research directions include investigating flipped classroom effectiveness across different mathematics topics beyond integral calculus, examining long-term retention effects through delayed posttests, exploring student perceptions and engagement through qualitative methods, and developing strategies to address technological barriers in resource-limited settings. Additionally, future studies might examine how flipped classroom approaches can be optimized for Islamic higher education contexts, potentially integrating religious and cultural values into instructional design. The potential for further development includes creating more accessible video formats compatible with mobile devices, developing supplementary materials for students with limited internet access, and training lecturers in effective flipped classroom facilitation techniques. (Fatila, M., Jasril, I. R., & Ayasrah, F. T., 2026)

The implications for practice suggest that mathematics educators in similar institutional contexts should consider implementing flipped classroom approaches while proactively addressing technological constraints through strategies such as providing videos on portable storage devices, optimizing video formats for mobile viewing, and establishing robust support systems for students experiencing difficulties with self-paced learning. With appropriate contextual adaptations, flipped classroom pedagogy offers promise for enhancing mathematics learning outcomes across diverse educational settings.

## 7. FUNDING

The author(s) received no financial support for the research, authorship, and/or publication of this article.

## 8. INSTITUTIONAL REVIEW BOARD STATEMENT

This study was conducted in accordance with established ethical standards for research involving human participants. The research protocol was reviewed and approved by the Human Research Ethics Committee. All participants were informed about the purpose of the study, the procedures involved, and their right to withdraw at any time without penalty. Participation was entirely voluntary, and all data were collected and maintained anonymously to ensure confidentiality. Written informed consent was obtained from all participants prior to data collection.

## REFERENCES

Ario, M. (2015). The application of mathematical reasoning and habits of mind through the problem-based learning and discovery learning. *Edusentris*, 2(1), 34-46.

Ario, M. (2017). Profil penguasaan materi matematika sekolah mahasiswa pendidikan matematika semester VI. *Aksioma*, 6(3), 385-392.

Ario, M., & Asra, A. (2018). Pengaruh pembelajaran flipped classroom terhadap hasil belajar kalkulus integral mahasiswa pendidikan matematika. *Anargya: Jurnal Ilmiah Pendidikan Matematika*, 1(2), 67-74.

Assessing the Relationship Between Mathematical Rigor and Metacognitive Thinking Among Secondary School Teachers. (2026). *Letters in Biomathematics*, *12*(2), 135-145. https://doi.org/10.30707/

Bhakti, Caraka Putra; Ardiyanti, Difa; Kumara, Agus Ria; and Ghiffari, Muhammad Alfarizqi Nizamuddin (2025) "Development of a Career Awareness Board Game based on Augmented Reality for Generation Z Students," *Buletin Konseling Inovatif*: Vol. 5: No. 3, Article 10.
DOI: https://doi.org/10.17977/um059v5i32025p324-334

Bishop, J. L., & Verleger, M. A. (2013). The flipped classroom: A survey of the research. In *120th ASEE Annual Conference & Exposition* (pp. 23-26). Atlanta, GA: American Society for Engineering Education.

Chandra, F. H., & Nugroho, Y. W. (2016). Peran teknologi video dalam flipped classroom. *Dinamika Teknologi*, 8(1), 15-20.

Fahrudhin, A. G., Zuliana, E., & Bintoro, H. S. (2018). Peningkatan pemahaman konsep matematika melalui realistic mathematic education berbantuan alat peraga bongpas. *Anargya: Jurnal Ilmiah Pendidikan Matematika*, 1(1), 14-20.

Fatila, M., Jasril, I. R., & Ayasrah, F. T. (2026). Interactive Macromedia Flash–

Based Learning Media for K3LH Instruction in Vocational Electronics Education. *Journal of Hypermedia & Technology-Enhanced Learning*, *4*(1), 1–15. https://doi.org/10.58536/j-hytel.209

Fatila, M., Jasril, I. R., & Ayasrah, F. T. (2026). Interactive Macromedia Flash–Based Learning Media for K3LH Instruction in Vocational Electronics Education. *Journal of Hypermedia & Technology-Enhanced Learning*, *4*(1), 1–15. https://doi.org/10.58536/j-hytel.209

Kurniadi, G., & Purwaningrum, J. P. (2018). Kemampuan pemahaman matematis siswa melalui discovery learning berbantuan asesmen hands on activities. *Anargya: Jurnal Ilmiah Pendidikan Matematika*, 1(1), 8-13.

Kurniati, A., Muhandaz, R., & Hamzah, F. A. (2017). Pengaruh penerapan metode pembelajaran kelompok buzz terhadap kemampuan komunikasi matematika siswa. *Suska Journal of Mathematics Education*, 3(2), 111-118.

Marhamah. (2016). Kompetensi profesional guru matematika. *Jurnal Dosen Universitas PGRI Palembang Edisi 4*. Retrieved from http://www.univpgri-palembang.ac.id/e_jurnal/index.php/prosiding/article/view/518

Muhammad Javed Khan, & Zafar, H. (2025). An Extended TOPSIS Method for the Multiple Attribute Decision Making Problems Based on double hierarchy linguistic soft sets (DHLSSs). *VFAST Transactions on Mathematics*, *13*(2), 41–54. https://doi.org/10.21015/vtm.v13i2.2161

Ni Luh Putu Gautami, Anak Agung Gede Agung, & Ida Bagus Gede Surya Abadi. (2025). An Interactive E-Worksheet Using the STAD Model on Phase Changes of Matter to Fourth Grade Students. *International Journal of Elementary Education*, *9*(2), 271–281. https://doi.org/10.23887/ijee.v9i2.94257

Noviarny, D. A., Murtono, & Ulya, H. (2018). Model think talk write berbantuan media monomat meningkatkan kemampuan komunikasi matematika siswa sekolah dasar. *Anargya: Jurnal Ilmiah Pendidikan Matematika*, 1(1), 21-28.

Pharamita, W., & Muchtar, B. (2016). Pengaruh model flipped classroom dan sikap siswa terhadap hasil belajar ekonomi. *Jurnal Kajian Pendidikan Ekonomi*, 3(1), 37-50.

Pratiwi, A., Sahputra, R., & Hadi, L. (2017). Pengaruh model flipped classroom terhadap self-confidence dan hasil belajar siswa SMAN 8 Pontianak. *Jurnal Pendidikan dan Pembelajaran*, 6(11), 1-13.

Putri, S., & Ibad, M. (2024). Pengembangan Media Keselamatan & Kesehatan Kerja, Dengan Teori Proses Di PT. Bogasari Flour Mills Surabaya. Karya: *Jurnal Pengabdian Kepada Masyarakat*, *4*(2), 118–125. Retrieved from https://jurnalfkip.samawa-university.ac.id/KARYA_JPM/article/view/586

Ridha, M., Setyosari, P., & Kuswandi, D. (2016). Pengaruh flipped mastery classroom terhadap perolehan hasil belajar kognitif mahasiswa. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, 1(4), 655-661.

Sa'idah, N., & Mhmd Habibi. (2025). Self-Regulated Learning Instrument Development for Social Science Subject of Elementary School Students. *ELSE (Elementary School Education Journal): Jurnal Pendidikan Dan Pembelajaran Sekolah Dasar*, *9*(1). https://doi.org/10.30651/else.v9i1.25094

Sibuea, F. P. J., & Paramita, A. S. (2025). Sistem Pendukung Keputusan Smart Leasing Value Asset dengan Perhitungan NPV dan NAL Berbasis Website. *Bulletin of Computer Science Research*, *6*(1), 175-182. https://doi.org/10.47065/bulletincsr.v6i1.897

Sijabat, C., Silaban, R., Eddiyanto, Nasution, H., Amdayani, S., Alexander, I., & Ridho, D. (2025). Development of an E-Module Based on the SAVI Learning Model on the Topic of Buffer Solutions. *EduMatSains : Jurnal Pendidikan, Matematika Dan Sains*, *10*(1), 76–87. https://doi.org/10.33541/edumatsains.v10i1.6784

Siregar, T. (2025). Studi Lintasan Pembelajaran dan Pengaruh Media Pembelajaran GeoGebra terhadap Pemahaman Turunan Fungsi Aljabar. *Bakti : Jurnal Pengabdian Kepada Masyarakat*, *5*(2), 27-45. https://doi.org/10.51135/bakti.5.2.27-45

Siregar, T. (2026). Improving Activity and Mathematics Learning Outcomes Through the Mind Map Method for Grade VIII Students at SMP Negeri 1 Sinunukan. *Available at SSRN 6021034*.

Siregar, T., & Fauzan, A. (2025). An Overview of Problem-Based Learning: Its Process and Impact on Learning. *Rusdinal and, Yerizon and Fauzan, Ahmad, An Overview of Problem-Based Learning: Its Process and Impact on Learning (November 08, 2025)*.

Siregar, T., & Fauzan, A. (2025). The Effectiveness of Realistic Mathematics Education (RME) on Students' Problem-Solving Skills and Mathematical Beliefs in Elementary School. *Yerizon and Fauzan, Ahmad, The Effectiveness of Realistic Mathematics Education (RME) on Students' Problem-Solving Skills and Mathematical Beliefs in Elementary School (November 17, 2025)*.

Siregar, T., & Keulen, H. V. (2026). Analysis of Student Errors in Solving Mathematics Problems on Trigonometry Materials Based on Newman's Analysis. *Available at SSRN 6013114*.

Studi Literatur: Analisis Model Borg And Gall Dalam Pengembangan Dan Penelitian Pendidikan. (2025) AT- Taklim *AT-TAKLIM: Jurnal Pendidikan Multidisiplin*, *2*(12), 226-237. https://doi.org/10.71282/at-taklim.v2i12.1327

Sugiyono. (2010). *Metode penelitian pendidikan pendekatan kuantitatif, kualitatif dan R&D*. Bandung: Alfabeta.

Sunarjo, W. A., Ari Muhardono, Titi Rahayu Prasetiani, & Mukhamad Adzhar Sultan. (2024). Pendapingan Strategi Pengelolaan Transformasi Digital: E-Business Strategy And Implementation. Socircle:*Journal Of Social Community Services*, *3*(1), 1–10. https://doi.org/10.58468/socircle.v3i1.19

Undang-undang Nomor 14 Tahun 2005 tentang Guru dan Dosen. [Law No. 14 of 2005 concerning Teachers and Lecturers]