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A FLIPPED CLASSROOM WITH MICRO-LEARNING BASED MODEL FOR ENHANCING STUDENT ACADEMIC OUTCOMES AND ENGAGEMENT IN BIOLOGY

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ABSTRACT
This study aimed to evaluate the impact of a micro-learning based flipped classroom model on the academic performance and engagement of first-year biology students at Minzu Normal University of Xingyi. Ninety students were recruited and assigned evenly into experimental and control groups, with 45 students each. The experimental group was exposed to the micro-learning based flipped classroom model, while the control group followed traditional teaching methodologies. The research was structured into four distinct phases. The initial phase involved collecting baseline data to ascertain both students' and teachers' perspectives on the current educational practices. The second phase was dedicated to the development of the flipped classroom model, which was then fine-tuned based on the feedback received from a panel of experts. The third phase of the study focused on the experimental deployment of the model, examining its effectiveness. The data revealed that the experimental group significantly outperformed the control group in terms of academic performance, as evidenced by improved scores on the post-tests. Furthermore, enhanced engagement levels were observed among the experimental group, as indicated by the post-

intervention surveys. The final phase of the study confirmed a strong preference among students for the micro-learning based flipped classroom model over traditional teaching approaches. The conclusive evidence from the study's results substantiates the effectiveness of the innovative teaching model, demonstrating notable improvements in both academic achievements and engagement among students who were taught using the flipped classroom methodology. These findings advocate for the integration of flipped classroom and micro-learning strategies to augment the learning experiences and outcomes in biology education. This research contributes essential insights into the potential for educational innovation to transform teaching and learning in higher education settings.
Key Words: Flipped Classroom, Micro-Learning, Biology

Introduction

Teaching technology keeps changing and there are many discussions on teaching methods. However, many new teaching methods have not been widely used in practical teaching. Especially in teaching mathematics, most them still adopt the traditional teaching mode of "teachers teach, students learn." This model focuses on the classroom and takes "definition-theorem-derivation-conclusion" as the main line of teaching and learning (Cevikbas & Kaiser, 2020). Teachers play a dominant role and teach only theoretical concepts. Students' practical ability is limited to the classic examples provided in textbooks and they lack the consciousness to actively find and solve problems in production and satisfy social needs (Marpa, 2021). Therefore, the traditional teaching and learning mode is rigid, information sharing is slow, and students' learning mode is simply imitating the teacher's actions and practicing. Students learn passively rather than actively. With passing times, the concept of higher education changed to meet the needs of the society for talents. especially for the practical ability and innovative ability of university graduates, and it has become necessary to reform teaching concepts, content, and methods. How to embody the thought of quality education in teaching, cultivate student innovative thinking, practical ability and innovative ability is now an urgent problem (Karalis & Raikou, 2020).

The flipped classroom model emerged as a response to these challenges by promoting active learning, personalized instruction, and increased student engagement (Busebaia & John, 2020). By shifting the delivery of content outside of class and using in-class time for interactive activities, the flipped classroom addresses many of the limitations of the traditional lecture-based approach and offers opportunities for more effective and engaging learning experiences (Lai et al., 2021). Micro-learning plays a crucial role in supporting the implementation and effectiveness of a flipped classroom. Firstly, micro-learning modules provide the necessary pre-class content that students study before class, which can be easily accessed by students outside the classroom. Secondly, micro-learning delivers content in bite-sized portions, which aligns well with the flipped classroom objective of breaking down complex concepts into manageable units. By providing concise and easily digestible content, micro-learning ensures that students can engage with the material at their own pace and review specific modules as needed. Thirdly, micro-learning resources are often accessible through digital platforms, making them available to students anytime and anywhere.

Students can revisit the micro-learning modules as necessary, providing them with a continuous and personalized learning experience (Romanenko et al., 2023).

Biology is a fascinating subject to teach. A recent biology conference in the United States, organized annually by the National Association of Biology Teachers, highlighted some of the key dilemmas and challenges for biology teachers. Inagaki & Hatana (2002) noted that all children entering school are curiosi about biology, that they have learned instinctively from the world and people around them. This gives teachers a starting point for helping students understand more about this highly relevant and important subject, because we, too, are part of the living world. When students are actively engaged, they learn more (Ueckert & Gess-Newsome, 2006). Hands-on experience is a commonly used by high school biology teachers, since it allows students to manipulate objects and conduct studies (Tunnicliffe & Ueckert, 2007). Teaching biology is especially difficult when students are denied access to laboratories for hands-on observation of fresh specimens and the lockdown restricted travel outside of students' homes (Nieto-Escamez & Roldán-Tapia, 2021). Micro-learning appears to be promising for education: Leong et al. (2020) reviewed work up until 2020 on it. The trends of microlearning development were also summarized since 1880s and microlearning had a crucial role to play as an on-demand, anytime and anywhere instructional and training tool (Corbeil & Corbeil, 2023).

As a result, my study investigated the effects of micro-learning-based flipped classroom on learning performance and engagement in biology. The problems related to current students based on literature review and initial responses from students and instructors can be summarized as: First, traditional teaching methods, like teacher-centered method, presentation teaching etc., have been inadequate education. Second, the needs and requirements from students for new and updated knowledge have moved to higher levels. Third, low engagement in classrooms has become more and more obvious, and students felt bored with classroom activities. Therefore, a new teaching strategy should be designed to handle increasing student needs. The new model described in this study combined a flipped classroom with micro-learning-based teaching. The following sections set out the research objectives, research questions and hypotheses based on this model.

Research Objectives

1. To study the needs of students and teachers in flipped classroom with micro-learning-based model.
2. To develop the flipped classroom with micro-learning-based model.
3. To compare student academic performance between experiment and control groups using flipped classroom with micro-learning-based.
4. To find the student engagement after the experiment.

Research Methodology

The study adopted a quantitative research methodology with a pretest-posttest control group design to investigate the impact of teaching strategies on first-year biology students at Minzu Normal University of Xingyi. Participants were high school students enrolled in a biology course, randomly assigned to a control group utilizing traditional teaching methods and an experimental group engaging with a flipped classroom with a micro-learning-based model. The independent variable was the teaching strategy, with the dependent variables being student academic performance and engagement.

STUDENT NEEDS Learning method, Learning resource, and Learning content
SUPPORTING THEORIES **Constructivism Theory**: Constructivism believes that knowledge is not imparted by teachers, but by learners in a context, that is, in a sociocultural context, with the help of others (including teachers, and learning partners), using necessary learning materials, through the construction of meaning. **Autonomous Learning Theory**: Students' cognitive capability has advanced to the point where they may create their own knowledge, reflect on their educational experiences, plan their future studies, and successfully complete their objectives.

INDEPENDENT VARIABLES	DEPENDENT VARIABLES
Teaching strategy: **1. Flipped Classroom with Micro-learning Based Model** Micro-videos designed by instructors will be uploaded into Superstar learning platform for students to preview the lessons before the class and do discussions and activities during the class and then send feedback up to the Superstar learning platform. **2. Traditional Teaching Method** The teacher will use traditional presentation teaching method in class.	**1. Student Academic Performance** Academic performance will be measured by a standard biology test paper which focuses on student five aspects based on Bloom's taxonomy: - Remember - Understand - Apply - Analyze and evaluate **2. Engagement** Engagement refers to how much the students engaged in the new teaching model. Based on the literature review the measurement of engagement will be based on four aspects: - Behavioral engagement - Cognitive engagement - Emotional engagement - Engagement autonomous

Figure 1 Conceptual framework

Data collection involved standardized tests to gauge academic performance and questionnaires to assess student and teacher attitudes towards the teaching methods. The sample comprised 90 students, split evenly into experimental and control groups, each with 45 students. Pretests were conducted to establish a baseline of academic proficiency. Post-intervention, posttests and questionnaires were distributed to evaluate the strategies' effectiveness and gather qualitative feedback.

Table 1 Demographics

Location	Xingyi City, Guizhou Province	25°9'45" N, 104°58'4" E
University	Minzu Normal University of Xingyi	25°5'52" N, 104°53'45" E
Type of University	General	
Participants	Male Female	
Course	Introduction to Biology	
Ages	18-20 21-25	
Years Studying Biology	5-10 11-15	
Sampling **Experimental** **Control**	90 45 45	Cluster Sampling

Ethical standards were maintained throughout the study, with participant consent and anonymity being paramount. Reliability and validity were prioritized, with pilot testing of the collection instruments to refine their accuracy.

Data Analysis

In the quantitative data analysis phase, the study employed an independent samples t-test to evaluate the academic performance of students. This statistical test was used twice: first, to compare the baseline academic proficiency between the control and experimental groups via the pretest scores, ensuring both groups started from an equivalent level of knowledge. Secondly, it was applied to the posttest scores to assess the impact of the flipped classroom with micro-learning-based model on academic outcomes, as compared to the traditional teaching method. The t-test provided a means to establish whether there were statistically significant differences in the average scores between the two groups, both before and after the intervention. Additionally, effect size calculations accompanied the t-test rsults, offering insights into the practical significance of the teaching strategies.

For the analysis of student engagement, the study utilized Multivariate Analysis of Variance (MANOVA). This advanced statistical test was chosen because it allowed for the simultaneous analysis of multiple dependent variables namely, the different aspects of engagement including behavioral, cognitive, emotional, and autonomous engagement that could be affected by the independent variable, which in this case was the teaching strategy. MANOVA was instrumental in identifying whether there were any significant differences in the overall engagement profiles of students subjected to the two different teaching methods.

To ensure a comprehensive understanding of the teaching models' impact, qualitative data from open-ended survey responses were analyzed through content analysis. This qualitative analysis provided depth and context to the quantitative findings, revealing nuanced details of students' and teachers' experiences with the teaching strategies. The combined use of t-tests for academic performance and MANOVA for engagement offered a robust statistical framework to validate the efficacy of the flipped classroom model over traditional methods, supporting the potential for innovative educational practices in enhancing student learning experiences.

Research Results

1. Student and teacher needs analysis

The analysis revealed both students and teachers recognize the necessity for innovative teaching methods that cater to evolving educational demands. From the 90 students' perspective, reported a mean score of 3.70 for learning method needs, signifying an endorsement for instructional approaches that are more dynamic and student-centric. Similarly, learning resource needs scored slightly higher at 3.82, suggesting a particular interest in access to diverse and innovative materials that support their educational journey. The learning content needs were rated at 3.77, implying a strong inclination towards content that is relevant, current, and presented in a manner that facilitates deeper understanding and retention. Overall, the aggregate mean of 3.76 across all areas highlights a clear preference for educational strategies that transcend traditional didactic techniques, pivoting towards those that foster interactive learning environments, as shown in table 2:

Table 2 Student needs for new teaching methods

Student Needs	M	S.D.	Sig.
1. Student learning method needs	3.70	0.81	Agree
2. Student Learning Resource Needs	3.82	0.88	Agree
3. Student Learning Content Needs	3.77	0.82	Agree
Total	3.76	0.84	Agree

Additionally, interviews with 45 students from the Experimental Group revealed insights into their educational needs. These students reflected on their experiences with the flipped classroom with Micro-Learning Teaching Model as opposed to traditional, teacher-centered methods. A nuanced view emerged, with students acknowledging the efficacy of teacher-centered methods in certain scenarios, particularly in presenting a structured approach to the comprehensive and complex subject of biology. Yet, there was a discernible preference for the flipped classroom model, which they felt better addressed their individual learning styles and fostered a deeper engagement with the subject matter.

In the context of the flipped classroom model, all 6 teachers from the qualitative study endorsed this innovative approach. They recognized its transformative potential in the teaching and learning of biology, empowering students with greater agency in their learning journey. The model was seen as a catalyst for enhanced student engagement and improved academic performance. Teachers observed that students in the flipped classroom were more involved and capable of understanding complex biological concepts, which translated into more active participation in discussions and practical activities. The teachers unanimously agreed that the flipped classroom, integrated with micro-learning, offers a more effective teaching strategy than traditional methods, with promising implications for optimizing student learning outcomes.

2. Development of the flipped classroom with micro-learning based model

The flipped classroom with micro-learning based model was meticulously developed in alignment with current pedagogical theories, aiming to provide a dynamic platform where students could engage with biological concepts across all phases of the learning cycle. This approach emphasized micro-learning to deliver focused content, allowing for self-paced student interaction that enhances both the learning process and the cultivation of independent study habits.

During the development phase, the model underwent a rigorous validation process conducted by five experts from the Minzu Normal University of Xingyi, whose specialties spanned education, pedagogy, and biology. Their critical assessment led to several significant improvements in the model. Enhancements to the content's interactivity were made to foster greater student engagement, while complex segments were simplified for improved comprehension. The learning platform was updated for better mobile accessibility, the sequence of learning modules was realigned with the curriculum's structure, and collaborative in-class activities were devised to capitalize on the pre-class learning experience.

The efficacy of the flipped classroom with micro-learning based model was substantiated through a methodical quality assessment using Item Objective Congruence (IOC), a pivotal measure of the model's alignment with educational objectives. The expert panel's evaluation informed targeted enhancements, culminating in a series of micro-videos that encapsulate key biological concepts in a concise and accessible manner. Each video, by design, is a compact module that integrates seamlessly into the overarching structure of the curriculum, serving as a vital component of the student-centric learning trajectory, as shown in table 3:

Table 3 Contents and schedule of micro videos

Title	Contents	Time (min)
1. Cell Membrane Structure	The cell membrane is one of the basic structures of a cell, primarily composed of a phospholipid bilayer and proteins. The phospholipid bilayer consists of hydrophobic fatty acid tails and hydrophilic	3.5

Title	Contents	Time (min)
	phosphate heads, forming a stable barrier that separates the internal and external environments of the cell. Membrane proteins are embedded within the phospholipid bilayer and serve various functions, including signal transduction, substance transportation, and maintenance of cell morphology	
2. Mitosis	Mitosis is a cell division process aimed at producing two cells with identical genetic material, typically occurring in cells with nuclei. The process involves a series of consecutive stages, including prophase (comprising prophase I and prophase II), spindle formation, chromosome alignment, and cytokinesis.	4.0
3. Reproductive Organs of Plants	Plant reproductive organs refer to specialized structures within the plant body responsible for reproduction, used to produce and disseminate the plant's genetic material. These organs include both male and female reproductive organs. Male reproductive organs are typically part of the flower and include the anthers and filaments. Female reproductive organs are usually certain parts of the flower, including the ovary, stigma, and style.	3.5
4. Plant Pigments	Plant pigments are chemical compounds found in plant cells that impart different colors to plants. These pigments include chlorophyll, carotenoids, anthocyanins, and so on.	3.0
5. Adenosine Triphosphate	Adenosine triphosphate (ATP) is a cellular energy molecule, widely present within the cells of organisms. Its molecular structure consists of adenine, ribose, and three phosphate groups. ATP stores chemical energy, which can be released within cells	3.0

Title	Contents	Time (min)
	and used to drive many biological processes such as cellular metabolism, transport, synthesis, and movement.	
6. Gene	Genes are the basic units that carry genetic information on the DNA molecule. They are functional segments that control the hereditary characteristics and biological processes of an organism. Genes can be transcribed and translated into proteins or non-coding RNA. Genes encode specific functions or features within an organism, such as the structure of proteins, regulation, metabolic pathways, etc.	3.0
7. Mendel's Genetic Law	Gregor Johann Mendel, an Austrian biologist, proposed a set of basic principles describing the transmission of genetic traits in the 19th century. These laws were derived from Mendel's systematic observations and analysis of hybridization experiments with peas. Mendel's three major laws of inheritance are as follows:Law of Segregation, also known as the principle of segregation.Law of Independent Assortment, also known as the principle of independent assortment.Law of Recombination, also known as the principle of genetic linkage.	5.0
8. Respiration	Respiration is the physiological process in which organisms utilize oxygen for oxidative metabolism to produce energy and release carbon dioxide. Within organisms, respiration is mainly divided into two stages: aerobic respiration and anaerobic respiration. Respiration is an essential process for sustaining the life activities of organisms, generating energy by oxidizing organic substances, and releasing carbon dioxide and water.	5.0

3. Comparison of student academic performance between experimental and control groups

The comparison of academic performance between the experimental and control groups underscored the efficacy of the flipped classroom with micro-learning based model. The paired sample t-test results showcased a notable increase in scores from pre-test to post-test within the experimental group (n = 45), which reported a mean difference of 12.311 with a standard deviation of 6.090, resulting in a t-value of 13.562 ($p < 0.0009$). The control group (n = 45) also showed improvement, albeit to a lesser extent, with a mean difference of 8.578, a standard deviation of 3.683, and a t-value of 15.622 ($p < 0.0009$). Collectively, the total mean difference for all participants was 10.444 with a standard deviation of 5.345 and a t-value of 18.539 ($p < 0.0009$), signifying overall positive changes in both groups, with a more pronounced effect observed in the experimental group, as shown in table 4:

Table 4 Change in test scores within groups before and after intervention

Test	**n**	**M**	**S.D.**	**t**	**p**
Experimental Group	45	12.311	6.090	13.562	<0.0009
Control Group	45	8.578	3.683	15.622	<0.0009
Total	90	10.444	5.345	18.539	<0.0009

Further reinforcing these findings, an independent t-test compared the pre-test and post-test scores between the experimental and control groups. The pre-test results showed no significant difference between the groups ($t(88) = 0.000$, $p = 0.516$), suggesting homogeneity at the outset of the study. However, the post-test results demonstrated a statistically significant difference in favor of the experimental group, with a mean score of 79.24 against the control group’s 75.51, leading to a t-value of 3.741 ($p < 0.0009$). This indicates a substantial improvement attributable to the flipped classroom with micro-learning based model, as shown in table 5:

Table 5 Group comparison of test scores pre- and post-intervention

Test	**Group**	**n**	**Mean**	**S.D.**	**t**	**p**
Pre-test	Experimental	45	66.93	6.750	0.000	0.516
	Control	45	66.93	6.390		
	Total	90	66.93	6.536		
Post-test	Experimental	45	79.24	4.773	3.741	<0.0009
	Control	45	75.51	4.693		
	Total	90	77.38	5.067		

These analyses affirm the efficacy of the flipped classroom with micro-learning based model in enhancing academic performance in biology. The evidence supports the notion that engaging with content through micro-learning videos and flipped classroom methodology significantly benefits students’ academic achievements over traditional teaching methods.

4. Assessment of student engagement using the flipped classroom with micro-learning based model

The engagement levels among students in the experimental group were notably higher than those in the control group. The data suggested that the flipped classroom model fostered a more interactive and immersive learning environment, leading to increased student interest and involvement in the learning process. According to the MANOVA results, the experimental group, which was subjected to the flipped classroom with micro-learning, displayed elevated levels of behavioral, cognitive, and emotional engagement compared to the control group. The increase in behavioral engagement was particularly significant, with an F-value of 12.736 and a p-value of 0.001, indicating a robust link between the teaching model and the proactive behaviors in the learning environment. Cognitive engagement, which reflects the depth of students' intellectual involvement and investment in learning, also saw an improvement, although to a lesser extent ($F = 4.124$, $p = 0.045$). Emotional engagement, encompassing the affective aspects of the learning experience such as interest and enjoyment, was notably enhanced as well ($F = 5.365$, $p = 0.023$). The only aspect of engagement that did not show a statistically significant difference was autonomous engagement, which involves students' self-directed participation ($F = 2.828$, $p = 0.096$). This suggests that while the flipped classroom model significantly improves certain dimensions of engagement, it may require additional strategies to equally foster autonomy in the learning process, as shown in table 6:

Table 6 Flipped classroom model impact on student engagement components

Engagement	**SS**	**df**	**MS**	**F**	**p**
Behavior	34.844	1	34.844	12.736	0.001
Cognitive	9.344	1	9.344	4.124	0.045
Emotion	8.711	1	8.711	5.365	0.023
Autonomous	4.900	1	4.900	2.828	0.096

In summary, the implementation of the flipped classroom with micro-learning based model has been empirically demonstrated to enhance student engagement in terms of behavior, cognition, and emotion, validating its effectiveness as an educational strategy within a biology teaching context.

Conclusion

The conclusion drawn from this study highlights the flipped classroom with micro-learning based model as a significant enhancer of student engagement and academic performance in biology education. The research demonstrated that students in the experimental group, who experienced the innovative teaching strategy, outperformed their peers in the control group who received traditional instruction. This finding is particularly compelling as it underscores the model's role in not only facilitating a deeper understanding of the subject matter but also in fostering a more active and participatory learning environment. The incorporation of micro-learning elements provided students with the flexibility to engage with the content at their own pace, a factor that likely contributed to the increased performance indicators.

Engagement, a critical component of the educational experience, was notably higher in the experimental group across several facets. Behavioral engagement was reflected in students' proactive participation in learning activities, while cognitive engagement was evident in their analytical and reflective responses to the content. Emotional engagement, denoting students' interest and positive feelings towards learning, was also elevated, underscoring the model's capacity to create a more enjoyable and stimulating educational climate. These dimensions collectively suggest that the flipped classroom model can significantly alter the educational dynamics, transforming passive learning into an interactive and meaningful experience.

This study's insights call for a re-evaluation of traditional teaching methods and encourage the adoption of flipped classrooms with integrated micro-learning strategies in educational curricula. By aligning instructional approaches with the needs of contemporary learners, educators can potentially unlock higher levels of academic achievement and student engagement. While the results are promising, they also pave the way for further research, particularly in exploring the longitudinal effects of such teaching models and their scalability across different disciplines and educational levels.

Recommendations

1. Recommendations for implementation

(1) It is recommended to integrate the Flipped Classroom with Micro-Learning model across biology curricula to enrich student engagement with course material and to foster a self-driven learning experience.

(2) Biology instruction should increasingly incorporate project-based learning, allowing students to undertake investigations that resonate with their individual scientific interests and real-world issues.

(3) Adoption of a student-centered instructional approach should be prioritized, emphasizing hands-on experiments, group discussions, and the application of biological concepts to contemporary scenarios to deepen understanding and retention.

2. Recommendations for future study

(1) Further research should explore the longitudinal effects of the Flipped Classroom with Micro-Learning model on student learning outcomes across diverse educational settings and disciplines.

(2) Comparative studies between different project-based learning frameworks within biology education could yield insights into the most effective strategies for various student demographics.

(3) Future investigations might also evaluate the efficacy of blending traditional and flipped classroom methodologies to determine optimal instructional designs for varying content complexities and student learning styles.

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