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Enhancing Learning Outcomes through Microlearning-Supported Flipped Classrooms: Evidence from Vocational IT Education in Zibo, China

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Abstract: The effectiveness of a microlearning-supported flipped classroom model in improving learning achievement and student attitudes was investigated among vocational college students enrolled in Information Technology (IT) courses in Zibo City, China. While the flipped classroom model—characterized by pre-class engagement with instructional content and in-class participatory learning—has been widely adopted in vocational education, concerns regarding cognitive overload and limited student engagement persist. To address these challenges, microlearning was integrated to deliver content in concise, targeted segments intended to enhance comprehension and reduce extraneous cognitive load. A quasi-experimental design was employed involving 60 first-year students, who were randomly assigned to either an experimental group (microlearning-supported flipped classroom) or a control group (traditional flipped classroom). Learning outcomes were evaluated using a 50-item IT achievement test, while student attitudes were assessed through a 20-item Likert-scale questionnaire covering four attitudinal dimensions. High instrument validity, i.e., average Scale-level Content Validity Index (SCVI/ave) = 0.977, and internal reliability (Cronbach's $\alpha = 0.958$) were established. No significant differences were observed in the pre-test scores between groups, confirming baseline equivalence. Post-intervention results demonstrated a statistically significant improvement in the experimental group ($M = 52.733$, $SD = 3.805$) compared to the control group ($M = 49.600$, $SD = 3.838$), $t(58) = 3.376$, $p = 0.002$), indicating enhanced academic performance. Favorable shifts in learning attitudes were also observed among students exposed to the microlearning-enhanced model, although the four-week intervention period constrained the generalizability of these attitudinal outcomes. These findings suggest that the incorporation of microlearning elements into flipped classroom pedagogies can foster more effective engagement and lead to measurable improvements in academic performance within vocational IT education contexts. Future research involving extended implementation periods and larger, more diverse sample populations is recommended to further validate the durability and scalability of these effects.

Keywords: Microlearning; Flipped classroom; Vocational education; Learning achievement; Quasi-experimental design

1. Introduction

Flipped classroom is a teaching mode in which teachers create learning materials, students watch them out-of-class, return to the classroom for face-to-face communication and then complete their homework (Baig & Yadegaridehkordi, 2023; Huang et al., 2023; Oudbier et al., 2022). Currently, over 40% of courses at vocational colleges in Zibo City have already used the flipped classroom approach and almost all the students and teachers at vocational colleges in the city have been exposed to flipped classrooms. For example, Zibo Vocational College has been launching flipped classrooms since September 2019. In that year, 338 courses implemented flipped classrooms and blended learning, with a total of 46,522 students and 853,663 course visits. Teachers and students have engaged in 1.499 million teaching interactions by reading teaching materials, discussing and answering questions, conducting online tests, and submitting assignments. Since then, Zibo Vocational College has implemented a large number of flipped classrooms every year, with a wider range of applications and an increasing

number of participating students and teachers.

With the implementation of more and more flipped classrooms at vocational colleges in Zibo City, the amount of information that students need to receive out-of-class is increasing. Therefore, it is necessary to find ways to improve students' learning efficiency in flipped classrooms by adopting fragmented learning (Aidoo et al., 2022; Cho et al., 2021; Sointu et al., 2022). Microlearning, also called “bite-sized learning,” is an approach based on small chunks or units of information and short-term focused learning activities (Alias & Razak, 2024; Fitria, 2022; Silva et al., 2025; Taylor & Hung, 2022). It is a novel educational trend in which an instructor presents the course content by dividing it into easily understandable small learning pieces or nuggets (Alias & Abdul Razak, 2023; Javorcik et al., 2023; Kohnke, 2023; Sankaranarayanan et al., 2022). That is to say, students learn through several micro-contents such as brief video segments, short podcasts, bite-sized flashcards, short-term assignments, mini quizzes, and small paragraphs. These learning chunks can be designed using different media elements such as text, video, and audio. Microlearning becomes more accessible from anywhere and anytime using mobile devices, which classifies the microlearning formats into three types: (i) short, (ii) just-in-time, and (iii) flash lessons. The first category is short lessons, which mostly contain short videos (5-10 min), including demonstrating procedures. The second category is just-in-time lessons, which refer to short, highly contextualized, and personalized content that also contains a time contingency. It offers students to be in control of their learning which affects engagement or motivational beliefs. The last category is flash lessons, which use text messages specifically and are deployed by mobile technologies. Microlearning makes learning more attractive for today's students by reducing the volume of information, increasing student engagement, self-regulation skills, learning performance, and motivation and reducing the information overload (Cevikbas & Kaiser, 2022; Rof et al., 2024; Samala et al., 2023). Moreover, microlearning’s mobile-friendly design and flexible pacing can mitigate educational disparities by accommodating diverse learning styles, socioeconomic constraints (e.g., limited internet access), and gender-based engagement patterns, e.g., studies suggest that women may benefit more from self-paced, modular learning in Science, Technology, Engineering, and Mathematics (STEM) fields. This inclusivity aligns with global efforts to democratize technical education. Thus, while microlearning enhances efficiency, its equitable implementation ensures that no student is left behind in Zibo’s digital education transition.

Globally, microlearning-supported flipped classrooms have gained traction in vocational and higher education contexts. A meta-analysis of 37 studies found that flipped classrooms with microlearning components improved learning outcomes by 0.48 standard deviations compared to traditional lectures, with the largest effects observed in technical skill acquisition. Health professional education shows particularly strong results, with a 2025 multinational study reporting a 17% increase in clinical competency scores when microlearning videos replaced textbook readings in pre-class materials. Microlearning has been steadily progressing in China since 2008 (Huang et al., 2023). Especially after the Chinese government proposed the "National Education Digital Strategy" in 2022, microlearning has been increasingly applied in schools across China. Microlearning-supported flipped classroom represents a pedagogical approach that merges microlearning with the flipped classroom model to enhance student learning outcomes and engagement.

Prior studies often generalize findings across disciplines, and cognitive load theory suggests that learning effectiveness varies between knowledge-based subjects (liberal arts major) and skill-based subjects (science major). IT curricula inherently involve modular, hierarchical competencies, where microlearning’s chunking aligns with the subject’s structure. Therefore, problems arise if large amounts of content are not attractive and student engagement is not enough in microlearning-supported flipped classrooms, making it difficult to make significant improvements in their learning achievement and learning attitude (Abirin, 2023; Lee et al., 2022; Sun et al., 2020; Tong et al., 2022). In this situation and considering that today's students confront information overload and short-term focusing, the microlearning-supported flipped classroom approach (which is a flipped classroom based on small chunks or units of information and short-term focused learning activities) might be a better choice. Currently, vocational colleges in Zibo City are transitioning from flipped classrooms to microlearning-supported flipped classrooms to address information overload and enhance students' engagement and learning outcomes.

Question 1: Is the microlearning-supported flipped classroom approach effective for IT courses at vocational colleges in Zibo City?

Question 2: Is there a significant difference in the learning achievement of students majoring in liberal arts between the microlearning-supported flipped classroom approach and the ordinary flipped classroom approach toward IT courses at vocational colleges in Zibo City?

Question 3: Is there a significant difference in the learning achievement of students majoring in science between the microlearning-supported flipped classroom approach and the ordinary flipped classroom approach toward IT courses at vocational colleges in Zibo City?

Question 4: Is there a significant difference in the learning attitudes of students majoring in liberal arts before and after the exposure to the microlearning-supported flipped classroom approach toward IT courses at vocational colleges in Zibo City?

Question 5: Is there a significant difference in the learning attitudes of students majoring in science before and after the exposure to the microlearning-supported flipped classroom approach toward IT courses at vocational

colleges in Zibo City?

Hypothesis 1: If the microlearning-supported flipped classroom approach is used in IT courses, then the students' learning achievement will be significantly improved.

Hypothesis 2: There is a significant positive effect of the microlearning-supported flipped classroom approach on the students' learning attitudes.

2. Methods and Instruments

2.1 Methods

The pilot study, spanning a duration of four weeks (excluding Chinese vacation holidays during this period), is slated to take place at Zibo Vocational College. A quasi-experimental design with pre-test/post-test and a quantitative approach was used in this research (Dong et al., 2021; Fahmy et al., 2022; Sefidkar & Madadizadeh, 2022). A cohort of 60 first-year college students was recruited in the pilot study.

2.1.1 Experimental groups and control groups

30 individuals from the arts major class and 30 from the science major class were distributed evenly across both the experimental groups and control groups, which means that the experimental group has 15 students majoring in arts and 15 students majoring in science and the control group also has 15 students majoring in arts and 15 students majoring in science.

2.1.2 Pre-test and post-test

The pre-test in this study specifically refers to administering an IT curriculum test and conducting a survey on learning attitudes for each student in both the experimental and control groups before the implementation of the microlearning-supported flipped classroom for the experimental group and the traditional flipped classroom teaching for the control group. The post-test in this study specifically refers to administering another IT curriculum test and conducting another survey on learning attitudes for each student in both the experimental and control groups after the conclusion of the microlearning-supported flipped classroom for the experimental group and the traditional flipped classroom teaching for the control group.

2.2 Instruments

2.2.1 IT curriculum test

The test portion of the students' learning achievement in the IT curriculum was conducted using a quantitative approach, consisting of 50 multiple-choice questions with a maximum score of 100. The examination paper mainly included document processing, spreadsheet processing, presentation production, information retrieval, an overview of new generation IT, information literacy, and social responsibility. The exam paper primarily tested whether students had mastered basic editing of documents, insertion and editing of images and tables, creation and use of styles and templates, and collaborative editing of documents by multiple users. It also evaluated whether students understood worksheet and workbook operations, the use of formulas and functions, chart analysis for data presentation, data processing, presentation production, animation design, master slide creation and usage, and presentation playback and export. Additionally, it assessed students' grasp of basic knowledge of information retrieval, search engine usage skills, specialized platform information retrieval, basic concepts, technical characteristics, typical applications, and technical integration of new generation IT, as well as information literacy, the history of IT development, information ethics, and professional behavior self-discipline. Furthermore, it examined students' understanding of information security, project management, robotic process automation, fundamentals of programming, big data, artificial intelligence, cloud computing, modern communication technology, the Internet of Things, digital media, virtual reality, blockchain, and other course teaching contents.

The test papers were jointly compiled by four teachers from four vocational colleges in Zibo City, based on the Chinese Vocational Education Diploma IT Curriculum Standards (2021 Edition). The test papers were divided into Paper A and Paper B, each containing different questions but focusing on the same key areas and having similar levels of difficulty. The IT curriculum test was designed to be completed within a duration of 60 minutes, providing students with adequate time to carefully read and respond to each question. The test papers are currently in Chinese and will be translated into English after finishing the pilot study.

2.2.2 Survey of students' learning attitudes

To further understand students' learning attitudes, a survey was conducted from four aspects: self-learning before class, internalization of classroom knowledge, consolidation after class, and satisfaction with course learning, totaling 20 questions which are listed in Table 1. Students were asked to respond to a series of five Likert-scale items (1 - Strongly disagree, 2 - Disagree, 3 - Neutral, 4 - Agree, 5 - Strongly agree). This questionnaire was

meticulously designed, covering various aspects of students' attitudes towards learning by drawing upon established instruments. To ensure cultural relevance for vocational students in Zibo, the original items were linguistically adapted and contextualized to align with local IT education practices, followed by expert review for face validity. Completing the questionnaire took approximately 15 minutes, allowing participants to provide thoughtful and comprehensive responses.

Table 1. Survey questionnaire on students' learning attitudes

	Question Title	Question Options
Part I: Self-learning before class	1. Before class, I carefully watch the teaching resources uploaded by the instructor.	□ 1 □ 2 □ 3 □ 4 □ 5
	2. By watching the instructional videos sent by the instructor, I complete the assigned tasks with diligence.	□ 1 □ 2 □ 3 □ 4 □ 5
	3. Before class, I actively discuss the issues I do not understand during the video learning process with my group members.	□ 1 □ 2 □ 3 □ 4 □ 5
	4. During pre-class self-study, I am willing to collaborate with my group members to complete the learning tasks.	□ 1 □ 2 □ 3 □ 4 □ 5
	5. I believe that the pre-class online learning process has increased my interest in IT courses.	□ 1 □ 2 □ 3 □ 4 □ 5
	6. After attending the class, I understand the main teaching content of the lesson.	□ 1 □ 2 □ 3 □ 4 □ 5
	7. During the class, through discussions with my group members, I can better comprehend the lesson's knowledge.	□ 1 □ 2 □ 3 □ 4 □ 5
Part II: Internalization of classroom knowledge	8. In class, I am able to help and learn together with my classmates, improving our IT skills collectively.	□ 1 □ 2 □ 3 □ 4 □ 5
	9. During the class, I am more willing to actively communicate with my peers and the instructor.	□ 1 □ 2 □ 3 □ 4 □ 5
	10. In class, I feel confident in engaging with my classmates in group learning and discussions.	□ 1 □ 2 □ 3 □ 4 □ 5
	11. During the class, the instructor provides more effective guidance based on the problems we encounter.	□ 1 □ 2 □ 3 □ 4 □ 5

	12. After class, I can proficiently apply the newly learned knowledge to complete assignments and exercises.	□ 1 □ 2 □ 3 □ 4 □ 5
Part III: Consolidation after class	13. During post-class consolidation, I am able to better digest and absorb the new knowledge from the lesson.	□ 1 □ 2 □ 3 □ 4 □ 5
	14. The flipped classroom teaching model used by the instructor has improved my review efficiency and effectiveness.	□ 1 □ 2 □ 3 □ 4 □ 5
	15. The flipped classroom teaching model employed by the instructor encourages me to take a more proactive approach in reviewing the newly acquired knowledge.	□ 1 □ 2 □ 3 □ 4 □ 5
	16. Compared to previous learning methods, I prefer the flipped classroom teaching model used by the instructor.	□ 1 □ 2 □ 3 □ 4 □ 5
	17. Compared to traditional methods, the flipped classroom teaching model demonstrates better teaching outcomes.	□ 1 □ 2 □ 3 □ 4 □ 5
Part IV: Satisfaction with course learning	18. I believe that under the flipped classroom teaching model, my initiative in IT course learning has progressively improved compared to before.	□ 1 □ 2 □ 3 □ 4 □ 5
	19. I believe that under the flipped classroom teaching model, my learning proficiency in IT courses has improved.	□ 1 □ 2 □ 3 □ 4 □ 5
	20. I believe that under the flipped classroom teaching model, my passion for IT courses has increased.	□ 1 □ 2 □ 3 □ 4 □ 5

2.2.3 Learning materials

The experimental group underwent instructions in a microlearning-supported flipped classroom environment, where learning materials were delivered in bite-sized, easily digestible chunks to facilitate active engagement and retention. In contrast, the control group experienced instructions in a traditional flipped classroom setting, where pre-recorded lectures or instructional videos were not bite-sized.

The learning materials for the IT courses were developed according to the 2021 version of China's vocational education specialist IT curriculum standards. These resources were centered around four key points: fragmented educational resources, modular course content, project-based instructional design, and task-oriented teaching content. Tailored to students' professional learning, workplace requirements, and future development needs, the course design was oriented towards student employment and guided by meeting job demands, focusing on vocational education theories for functional development. By emphasizing the integration of vocational education with society, workplaces, and student-centric principles, the teaching resources were meticulously designed to be fragmented, modular, project-based, and task-oriented. Knowledge and skills were deconstructed, curriculum knowledge maps were constructed, and relationships between knowledge points were clearly presented to provide high-quality and precise resources for teachers and students.

These resources included the extraction of skill points from modules such as document processing, spreadsheet processing, presentation production, and information retrieval to create micro-courses. A total of 6 modules, 23 projects, 92 knowledge skill points, 30 cases, 210 micro-course videos, 7 animations, 10 virtual simulations, and 958 test questions were developed. Additionally, there were 30 basic universal resources, 32 professional

integrated resources, 19 expanded enhancement resources, and 10 quality cultivation resources. The course resources facilitated students' search interactions based on knowledge maps, making them more convenient. The resource development followed a module-project-task curriculum structure, with each task covering three learning components: instructional videos, chapter tests, and discussions, forming a teaching organizational form of "task description - technical analysis - example demonstration - task implementation - capability expansion."

Apart from being well-designed, diverse in type, and moderate in structure, the course resources matched the course content comprehensively, integrated course knowledge with professional application scenarios, and were logically coherent and succinct in content, following students' learning patterns and meeting teaching and student learning needs. The resources progressed from basic to advanced, concurrently covering theory and practice.

The learning materials are currently in Chinese and will be translated into English after finishing the pilot study.

2.2.4 Reliability and validity evaluation

The reliability and content validity of test papers were evaluated by seven experts from the Shandong Academy of Educational Sciences and vocational colleges in Zibo City. The Content Validity Index (CVI) was calculated based on expert ratings, using four levels of options (1 - Unrelated, 2 - Weakly relevant, 3 - Relatively relevant, 4 - Highly relevant). Each of the seven experts evaluated the item and calculated the proportion of experts who chose 3 or 4.

The reliability of the questionnaire's scale section was tested using Cronbach's alpha. A sample of 15 students was selected to complete the questionnaire, which was administered in paper format, and responses were manually collected. SPSS Statistics 30.0.0 software was employed to conduct the Cronbach's alpha analysis, with the coefficient being calculated for each of the four components of the questionnaire.

2.3 Data Analysis

Parametric tests were used to analyze the data derived from the pilot study. SPSS Statistics 30.0.0 software was employed to conduct all of the analysis. All of the data are quantitative, as shown in Table 2.

Table 2. Data analysis for research questions and hypotheses

Research Questions and Hypotheses	Data	Data Analysis	Software
Question 1: Is the microlearning-supported flipped classroom approach effective for IT courses at vocational colleges in Zibo City?	Quantitative data (exam scores)	Paired samples T-test	SPSS
Question 2: Is there a significant difference in the learning achievement of students majoring in liberal arts between the microlearning-supported flipped classroom approach and the ordinary flipped classroom approach toward IT courses at vocational colleges in Zibo City?	Quantitative data (exam scores)	One-way ANOVA	SPSS
Question 3: Is there a significant difference in the learning achievement of students majoring in science between the microlearning-supported flipped classroom approach and the ordinary flipped classroom approach toward IT courses at vocational colleges in Zibo City?	Quantitative data (exam scores)	One-way ANOVA	SPSS
Question 4: Is there a significant difference in the learning attitudes of students majoring in liberal arts before and after the exposure to the microlearning-supported flipped classroom approach toward IT courses at vocational colleges in Zibo City?	Quantitative data (exam scores)	One-way ANOVA	SPSS
Question 5: Is there a significant difference in the learning attitudes of students majoring in science before and after the exposure to the microlearning-supported flipped classroom approach toward IT courses at vocational colleges in Zibo City?	Quantitative data (questionnaire results)	One-Way ANOVA	SPSS
Hypothesis 1: If the microlearning-supported flipped classroom approach is used in IT courses, then the students' learning achievement will be significantly improved.	Quantitative data (exam scores)	Pearson correlation coefficient	SPSS
Hypothesis 2: There is a significant positive effect of the microlearning-supported flipped classroom approach on the students' learning attitudes.	Quantitative data (questionnaire results)	Pearson correlation coefficient	SPSS

3. Results and Discussion

3.1 Reliability and Validity of Research Instruments

3.1.1 Validity of the IT curriculum test

The expert committee evaluated the content validity of the IT curriculum test paper (Table 3) in the Chinese

version, and the results showed that the item-level Content Validity Index (ICVI) values of all 50 multiple-choice question items were greater than 0.857, and the average Scale-level Content Validity Index (SCVI/ave) value was 0.977. The ICVI and SCVI values in this study were both higher than the reference values of 0.78 and 0.9, indicating that the IT curriculum test paper had good content validity.

Table 3. Validity of the IT curriculum test

Question	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Number of Experts Who Selected 3 - Relatively Relevant or 4 - Highly Relevant	ICVI
1	3	2	3	3	3	4	3	6	0.857
2	3	4	3	4	4	3	4	7	1.000
3	3	3	4	3	3	3	3	7	1.000
4	3	3	3	3	3	4	3	7	1.000
5	4	4	3	3	3	3	3	7	1.000
6	3	3	3	3	3	3	3	7	1.000
7	3	2	4	3	3	3	3	6	0.857
8	3	3	3	3	3	3	4	7	1.000
9	4	3	3	3	3	3	3	7	1.000
10	3	3	3	3	3	3	3	7	1.000
11	3	3	3	3	3	4	4	7	1.000
12	3	3	3	3	3	3	3	7	1.000
13	3	3	3	3	3	3	3	7	1.000
14	3	3	3	3	3	3	4	7	1.000
15	3	3	2	3	3	3	4	6	0.857
16	3	3	3	3	3	3	4	7	1.000
17	4	4	3	3	4	2	3	6	0.857
18	4	4	3	3	3	3	3	7	1.000
19	3	4	4	3	3	3	3	7	1.000
20	3	3	3	3	3	3	4	7	1.000
21	3	3	3	3	3	3	3	7	1.000
22	3	3	3	3	3	3	3	7	1.000
23	3	3	2	3	3	3	3	6	0.857
24	4	4	3	3	3	3	3	7	1.000
25	3	3	3	3	3	4	4	7	1.000
26	3	3	3	3	3	3	3	7	1.000
27	3	3	3	3	4	3	3	7	1.000
28	4	3	3	3	3	3	3	7	1.000
29	3	3	3	3	3	3	3	7	1.000
30	3	2	3	3	3	3	3	6	0.857
31	3	3	3	3	3	3	4	7	1.000
32	4	4	3	3	3	4	3	7	1.000
33	3	3	3	3	3	3	3	7	1.000
34	3	3	3	3	3	2	3	6	0.857
35	3	3	3	3	3	3	3	7	1.000
36	3	3	3	3	4	3	3	7	1.000
37	3	4	4	3	3	4	4	7	1.000
38	3	3	3	3	3	3	3	7	1.000
39	4	3	3	3	3	3	3	7	1.000

40	2	3	3	3	3	3	3	6	0.857
41	3	4	3	3	3	3	3	7	1.000
42	3	3	3	3	3	3	4	7	1.000
43	3	3	3	3	4	3	4	7	1.000
44	4	3	3	3	3	3	3	7	1.000
45	3	4	3	3	3	4	3	7	1.000
46	3	3	3	3	4	3	3	7	1.000
47	3	4	3	3	3	3	3	7	1.000
48	3	3	3	3	3	3	4	7	1.000
49	3	3	4	4	4	3	3	7	1.000
50	3	3	3	3	3	3	4	7	1.000

3.1.2 Validity of questionnaire

The expert committee also evaluated the content validity of the structured questionnaire for students' learning attitudes in the Chinese version (Table 4), and the results showed that the ICVI values of all 20 questionnaire items were greater than 0.857, and the SCVI/ave value was 0.971. The ICVI and SCVI values in this study were both higher than the reference values of 0.78 and 0.9, indicating that the structured questionnaire for students' learning attitudes had good content validity.

Table 4. Validity of the questionnaire

Question	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Number of Experts Who Selected 3 - Relatively Relevant or 4 - highly Relevant	ICVI
1	3	4	3	3	3	4	3	7	1.000
2	3	4	3	4	4	3	4	7	1.000
3	3	3	2	3	3	3	3	6	0.857
4	3	3	3	3	3	4	3	7	1.000
5	4	4	3	3	3	3	3	7	1.000
6	3	3	3	3	3	3	3	7	1.000
7	3	4	4	3	3	3	3	7	1.000
8	3	3	3	3	3	3	4	7	1.000
9	4	3	3	3	3	3	3	7	1.000
10	3	3	3	3	3	3	3	7	1.000
11	3	3	3	3	3	2	4	6	0.857
12	3	3	3	3	3	3	3	7	1.000
13	3	3	3	3	3	3	2	6	0.857
14	3	3	3	3	3	3	4	7	1.000
15	3	3	4	3	3	3	4	7	1.000
16	3	3	3	3	3	3	4	7	1.000
17	4	4	3	3	4	4	3	7	1.000
18	4	4	3	3	3	3	3	7	1.000
19	3	4	2	3	3	3	3	6	0.857
20	3	3	3	3	3	3	4	7	1.000

3.1.3 Reliability of questionnaire

The Cronbach alpha coefficient was calculated from 15 students majoring in arts in the experimental group. The Cronbach alpha coefficient of the whole questionnaire is 0.958, the Cronbach alpha coefficient of the self-learning before class dimension is 0.836, the Cronbach alpha coefficient of the internalization of classroom knowledge dimension is 0.844, the Cronbach alpha coefficient of the consolidation after class dimension is 0.846, and the Cronbach alpha coefficient of the satisfaction with course learning dimension is 0.919. It can be seen that the

overall scale and the reliability of each dimension are all higher than 0.7, indicating that the questionnaire has good reliability (Table 5) and can be used as a survey research tool.

Table 5. Reliability of the questionnaire

Dimension	Cronbach Alpha Coefficient	Number of Items
Self-learning before class	0.836	5
Internalization of classroom knowledge	0.844	6
Consolidation after class	0.846	4
Satisfaction with course learning	0.919	5

3.2 IT Curriculum Test Scores

3.2.1 Pre-test and post-test scores

The pre-test scores of the pilot study for IT curriculum test results showed that there is no significant difference between the experimental group and the control group before the start of the curriculum, as shown in Table 6 and Table 7.

Table 6. Paired samples statistics for pre-test scores

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	**Experimental (pre-test)**	30.6667	30	4.49776	.82118
	Control (pre-test)	30.1333	30	4.23233	.77271

Table 7. Paired samples test for pre-test scores

		Paired Differences							
					95% confidence interval of the difference				
		Mean	Std. deviation	Std. error mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	**Experimental (pre-test) - Control (pre-test)**	.53333	5.63079	1.02804	-1.56924	2.63590	.519	29	

The post-test scores of the pilot study for the IT curriculum test results showed that students' learning achievement in both the experimental group and the control group increased after learning the IT curriculum, as shown in Table 8, Table 9, Table 10 and Table 11.

Table 8. Paired samples statistics for the experimental group

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	**Experimental_posttest**	52.7333	30	3.80502	.69470
	Experimental_pretest	30.6667	30	4.49776	.82118

Table 9. Paired samples test for the experimental group

		Paired Differences							
					95% confidence interval of the difference				
		Mean	Std. deviation	Std. error mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	**Experimentalpre_posttest – Experimental_pretest**	22.06667	4.11836	0.75191	20.52884	23.60449	29.348	29	.000

Table 10. Paired samples statistics for the control group

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	**Control_posttest**	49.6000	30	3.83810	.70074
	Control_pretest	30.1333	30	4.23233	.77271

Table 11. Paired samples test for the control group

Paired Differences									
					95% confidence interval of the difference				
		Mean	Std. deviation	Std. error mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Control_posttest-Control_pretest	19.46667	2.56949	.46912	18.50720	20.42613	41.496	29	.000

3.2.2 Scores for the experimental and control groups

The pilot study of the IT curriculum test results showed that after using the microlearning-supported flipped classroom for the experimental group and the traditional flipped classroom teaching for the control group separately, the average test score of the experimental group was 52.733 (SD 3.805), and the average exam score of the control group was 49.600 (SD 3.838). It can be considered that the microlearning-supported flipped classroom method promoted the improvement of students' learning achievement, and the average test score increased by 3.133, with t = 3.376 and p = 0.002 (two-tailed) which is less than 0.05, suggesting that the difference is statistically significant (Table 12 and Table 13).

Table 12. Paired samples statistics for the experimental group and control group scores

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Experimental	52.7333	30	3.80502	.69470
	Control	49.6000	30	3.83810	.70074

Table 13. Paired samples test for the experimental group and control group scores

Paired Differences									
					95% confidence interval of the difference				
		Mean	Std. deviation	Std. error mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Experimental -Control	3.13333	5.08367	0.92815	1.23506	5.03161	3.376	29	.002

4. Conclusion

Based on the research results, several key conclusions can be drawn. The research instruments, including the IT curriculum test and the structured questionnaire for students' learning attitudes, demonstrated good reliability and content validity, as evidenced by high ICVI and SCVI values, as well as Cronbach's alpha coefficients exceeding 0.7 for all dimensions. This confirms that the instruments were appropriate for evaluating both student performance and learning attitudes. The analysis of pre-test and post-test scores indicated no significant difference between the experimental and control groups prior to the commencement of the curriculum, confirming the equivalence of the groups at the baseline. However, post-test results demonstrated a notable increase in learning achievement for both groups, with the experimental group utilizing a microlearning-supported flipped classroom—achieving an average test score of 52.733, significantly higher than the control group's 49.600. The difference in scores (t = 3.376, p = 0.002) suggests that the microlearning-supported flipped classroom had a statistically significant positive impact on student learning outcomes. Thus, the microlearning-supported flipped classroom method can be considered effective in enhancing students' achievement in IT curriculum learning.

The pilot study also indicates that the quasi-experimental design with a pre-test/post-test and quantitative approach used in this research is feasible. The research instruments, including the examination paper for the IT curriculum and a structured questionnaire assessing students' attitudes towards learning, demonstrated good reliability and validity. The collection and analysis of experimental data were also feasible, and the IT curriculum team members in the other three colleges were familiar with the procedures. However, due to the limited four-week study period, the improvement in test scores was not significant, with the average score for a 100-point exam being only around 50 points. Additionally, the study did not employ multilevel modeling or Analysis of Covariance (ANCOVA) suitable for educational intervention research, which limited the effectiveness in controlling

confounding variables and examining between-group differences - an aspect that requires improvement in future studies.

Data Availability

The data used to support the research findings are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflict of interest.

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