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Article

Investigation of Flipped-classroom in Engineering EMI Course: University EFL Students' Learning Experience

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Abstract: This comprehensive study delves into the implementation and effectiveness of the flipped classroom model in Engineering EMI (English as a Medium of Instruction) courses in Taiwan. Situated within the strategic framework of Taiwan's Bilingual Nation 2023 policy, this research aims to enhance the global competitiveness of Taiwan's semiconducting manufacturing engineering sector. The study's primary focus is on understanding the perceptions and learning outcomes of EFL (English as a Foreign Language) students in the engineering courses. Through a methodical approach using descriptive statistics and chi-square tests, the study analyzes data from 33 junior engineering students specializing in mechanical and mechatronic fields. The findings highlight a significant positive influence of the flipped classroom model on various aspects of student learning, including increased engagement, heightened creativity, and enhanced problem-solving skills. Additionally, the study emphasizes the critical role of timely L1 support in facilitating effective learning in EMI settings. These outcomes not only demonstrate the flipped classroom's viability as a sustainable educational approach but also provide crucial insights for educators and policymakers. By aligning cutting-edge teaching methods with the evolving needs of engineering education, this study contributes to the discourse on educational innovation. It ultimately guides the development of future engineering programs that cater to diverse student needs and fosters the cultivation of skilled engineering professionals.

Keywords: sustainability in engineering education; flipped classroom in EMI; educational transformation in engineering; higher education; L1 support in EMI contexts; student engagement in EMI; engineering education pedagogy; EMI course design and effectiveness; EFL (English as a Foreign Language) students; educational innovation in engineering

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1. Introduction

Taiwan's semiconductor manufacturing engineering, renowned worldwide, plays a critical role in expanding the nation's overseas markets. Strengthening international competition is a key priority, and one effective strategy is to enhance internationalization by promoting English as a lingua franca [1]. In higher education, particularly in non-Anglophone countries, the active implementation of English as a Medium of Instruction (EMI) is pivotal [2]. Developing effective English language capabilities within this context is an essential educational challenge.

The recent national policy, 'Bilingual Nation 2030,' has significantly influenced the design and introduction of EMI courses in Taiwan's higher education system. The primary objectives of the 'Blueprint for Developing Taiwan into a Bilingual Nation by 2030' include enhancing the bilingual educational system, improving English proficiency, and boosting overall competitiveness in Taiwanese society by 2030 (National Development Council, 2018). In response, the Ministry of Education encourages Taiwanese universities to participate in the EMI project, a program promoting bilingual education for college students (MOE, 2021). Consequently, many universities have begun preparing, designing, and introducing EMI courses. However, these institutions face challenges due to the government's top-down EMI policies in non-English-speaking environments [3]. Providing instructors with sufficient teaching resources and models for effective EMI instruction is crucial. According to [3], three critical misalignments include limited English proficiency among students enrolling in EMI courses, ambiguities in defining EMI, and conflicting student learning needs. These issues can hinder instructors from effectively imparting professional knowledge in EMI settings and lead to students encountering obstacles such as limited English proficiency and unmet learning needs.

In Taiwan, implementing EMI in engineering higher education reflects global educational trends, offering unique challenges and opportunities. The international engineering community increasingly adopts EMI to facilitate global collaboration and knowledge exchange, essential in the interconnected engineering field. This underscores the necessity of English proficiency for engineers in a multicultural and multinational context. Simultaneously, there is a significant shift towards active learning pedagogies, including flipped classrooms, which are gaining recognition globally for enhancing critical thinking and problem-solving skills—key competencies in engineering education.

Flipped classrooms represent an innovative, learner-centered pedagogical method [4]. Contrary to traditional instructor-centered models, where lectures are given in class and homework is assigned afterward, flipped classrooms involve pre-recorded video lectures for students to watch before class, followed by in-class time dedicated to collaborative and interactive activities [5]. This approach allows students, especially those needing more time, to learn at their own pace and actively engage in tasks like problem-solving with peers. The flipped classroom model offers varied, flexible, and compelling learning experiences.

Despite the recognized benefits of flipped classrooms, there is a significant gap in research regarding their effectiveness in EMI settings for engineering education in Taiwan. This study aims to fill this gap by exploring the impact of flipped classroom on student outcomes in EMI environments, focusing on English proficiency and understanding of engineering concepts. This research is vital for assessing the extent to which flipped classroom methodologies can enhance international competitiveness in engineering industries and aid in developing engineering talent in Taiwan.

This study aims to strengthen students' English abilities and professional engineering knowledge by designing EMI engineering courses incorporating flipped classroom techniques. The research questions are as follows:

1. What are students' perceptions of the engineering EMI course when taught through a flipped classroom approach?
2. How does students' English usage impact their learning experience using a flipped classroom model in engineering EMI course?
3. How does this approach affect students' learning achievements?

2. Literature

2.1. EMI in Higher Education

As globalization intensifies competition in higher education, English Medium Instruction (EMI) has become an increasingly essential trend in universities worldwide, particularly in non-Anglophone countries [1,3,6-10]. EMI is defined as teaching academic subjects in English in regions where English is not the first language [11-13]. English's rise as the dominant global language, driven by global commercial needs and the predominance of English in academic publications, has propelled this trend [1,6,7,10]. Consequently, universities worldwide are increasingly designing and offering EMI courses or programs to local and international students. These courses aid in developing students' language abilities, intercultural awareness, and international communication skills, enhancing their mobility and career competitiveness [10]. Furthermore, EMI courses contribute to the global prestige of universities, attract more international students and faculty, and bolster local students' career prospects [1,3,6,8,10].

With the rapid global emergence of EMI, significant challenges arise, particularly relating to students' limited English proficiency and their grasp of academic knowledge within the EMI curriculum [14-18]. The research on EMI courses indicated that students' academic success is influenced by their English proficiency, academic self-concept, and self-efficacy [14]. Lin and Lei observed that academic outcomes in English-taught courses were stronger predictors of success than English proficiency [15]. Additionally, vocabulary knowledge has been identified as a critical factor in academic achievement and self-perception among students, with a significant correlation between vocabulary knowledge and academic success [16].

Moorhouse and Wan's study revealed that postgraduate students in EMI universities faced three primary challenges: academic writing, understanding course contents, and oral production [18]. Additionally, students in EMI courses encountered difficulties with English comprehension and a lack of student-centered pedagogy [19]. Yıldız, Soruç, and Griffiths observed that students in Turkish universities experienced challenges in EMI courses, including difficulties with technical vocabulary, inadequate English usage by lecturers, code-switching, the English preparatory year curriculum, English language skills, and a lack of language support [20]. Zhang and Pladevall-Ballester noted a decline in students' attitudes toward EMI courses over time, which they attributed to these challenges [21]. These findings highlight the significant correlation between English proficiency, academic ability, and learning performance in EMI courses.

Adopting the first language (L1) in EMI courses is positively suggested to enhance learning outcomes [22-24]. Students' struggles in monolingual English classrooms due to limited English proficiency underscore the need for L1 support in EMI courses [25]. Kim, Kweon, and Kim's study indicated that students in three Korean engineering schools preferred L1 instruction over EMI, citing insufficient English proficiency [22]. L1 can be a valuable pedagogical resource, enhancing student engagement in EMI courses; however, its use is less prevalent in elite universities [23]. Additionally, four strategies for L1 use in EMI include domain-specific knowledge, complementing English, recast, and localizing knowledge [24]. Yuksel, Soruçet, Altay, and Curle demonstrated that students in EMI courses significantly improved their English proficiency, predicting their academic achievement in engineering and social sciences EMI programs [26]. Similarly, Soruçet, Mehmet, Samntha, and Dogan found that English proficiency significantly predicted academic language-related challenges in International Relations and Electronic Engineering [27]. Coşgun and Hasırcı reported significant improvements in reading, listening, and overall English proficiency among students at an EMI university [28]. Rose, Curle, Aizawa, and Thompson further investigated that English proficiency and academic English skills were significant predictors of success in EMI [29]. Conversely, Curle, Yuksel, Soruç, and Altay argued that general English proficiency is not a statistically significant predictor of academic success in EMI programs [30].

Tamtam, Gallagher, Olabi, and Naher posited that EMI's potential to improve English proficiency could enhance graduates' job prospects [31]. Tulsi found that mechanical engineering students greatly preferred active, sensing, visual, and sequential learning styles [32], indicating a need for reform in traditional engineering education [31,33]. Wilange and Nupong observed that study programs, language proficiency, and perceived language skills shape students' attitudes toward EMI, especially among engineering and nursing students [34]. Yuksel, Soruç, Altay, and Curle noted that self-regulation skills significantly predict academic success in EMI engineering courses [26].

The impact of EMI on higher education is multifaceted, encompassing university internationalization, teaching resources, and improvement in students' English proficiency. Higher education internationalization involves various aspects, including ideals, social and economic objectives, management, policies, instructors, and students [35]. Implementing EMI can facilitate this internationalization by creating an English environment, enhancing academic competence, and increasing motivation [36]. Zhang and Lütge emphasize the widespread adoption of EMI in universities [2].

However, the success of EMI in higher education is not without challenges. Byun, Chu, Kim, Park, Kim, and Jung highlighted that the effectiveness of EMI policy depends on factors like language proficiency, support systems, and instructor preparation [37]. Moreover, studying in EMI does not guarantee better learning outcomes than native language instruction [35]. Thus, while EMI offers significant advantages, its implementation demands careful consideration and support to ensure beneficial outcomes for all stakeholders.

2.2. Flipped-classroom

The flipped classroom plays a vital role in modern education, offering numerous benefits such as enhanced learning performance and outcomes, increased engagement, improved critical thinking, flexible learning preferences, effective learning, boosted motivation, and enriched social interaction [4,5,38-40]. Akçayır and Akçayır observed a consistent improvement in student learning performance through flipped classrooms in their extensive literature review [38]. Baig and Yadegaridehkordi suggested that flipped learning effectively enhances student engagement and outcomes, adapting well to evolving educational environments [39]. Ma found that flipped classrooms significantly enhanced students' critical thinking skills, applicable across various courses, including business studies [4].

Students in flipped classrooms exhibited more positive attitudes toward course activities and demonstrated deeper engagement with the content [40]. Mok highlighted the flexibility of flipped classrooms, allowing students to access video lectures as needed, which significantly aided their learning process [5]. Andrini, Pratama and Maduretno showed that combining flipped classrooms with project-based learning markedly improved students' critical thinking abilities in elementary clarification, essential support, inference, and advanced clarification [41]. Yulian noted that Indonesian university students experienced enhanced critical thinking and positive perceptions of the flipped classroom model [42]. Furthermore, integrating flipped classrooms with other teaching methods and technologies has been found to improve student effectiveness and develop critical thinking skills [43]. Underrepresented and first-year undergraduate students can benefit from critical thinking skills fostered by integrated flipped classrooms with active learning strategies [44].

The flipped classroom model has positively impacted student performance and engagement in higher education [45,46]. Generation Z students, in particular, have experienced success with the flipped classroom model in the 21st century [45]. Implementations of flipped classrooms have significantly enhanced student engagement and learning performance [47], and these models in universities are instrumental in cultivating students' critical and independent thinking, which is essential for their future endeavors [46]. Furthermore, flipped classroom models in higher education positively influence students' learning performance and academic achievements. They also render educational models more effective by adopting time-efficient, learner-centered approaches [46]. However, challenges such as addressing absenteeism, technical difficulties, and providing high-quality online resources must be managed [47]. Overall, the flipped classroom model holds significant potential in enhancing the learning experience and offering effective teaching models in higher education.

The application of the flipped classroom in engineering education significantly benefits student learning, encompassing effective learning, enhanced social interaction, problem-solving abilities, flexible learning, and improved learning achievement [48-54]. Problem-solving, an essential aspect of engineering courses, often involves innovative approaches [39]. The flipped classroom facilitates active participation through discussion, exercises, and feedback, proving beneficial in engineering education.

Prevalla and Uzunboylu's research demonstrated that flipped-classroom models employing dynamic group-based problem-solving activities effectively engaged students in active learning, critical thinking, and developing new study skills [53]. Cho, Zhao, Lee, Runshe, and Krousgrill found that students perceived these methods as valuable and beneficial for course preparation [50]. Marks, Ketchman, Riley, Brown, and Bilec reported the flipped classroom's positive and successful impact in sustainable engineering courses [55]. As noted by students, this approach led to deeper insights, enhanced problem-solving strategies, improved critical-thinking skills, increased self-confidence, and better teamwork abilities [56]. Kerr highlighted high student satisfaction and performance in flipped classroom settings [57]. Chiquito, Castedo, Santos, López, and Alarcón observed that students in flipped classroom groups demonstrated higher exam performance [58]. Mason, Shuman, and Cook

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noted initial struggles with the flipped classroom model among engineering students, but they ultimately achieved improved learning outcomes, including in exams, quizzes, and open-ended problems [59].

In EMI courses, flipped classrooms enhance learning through peer cooperation, addressing linguistic and other challenges [60-62]. They provide valuable support to EFL students in academic professional courses. For instance, Chou reported that students perceived the flipped classroom positively in EMI courses, enhancing their English comprehension [62]. The model supports interactive and collaborative work, aligning with task-based, communicative-oriented models [60].

2.3. Sustainable Learning

Sustainable Learning and Education (SLE) represents an emerging philosophy in learning and teaching grounded in sustainability principles. Unlike education solely for sustainability, SLE encompasses a broader scope [63]. Hays and Reinders articulate that SLE aims to create and disseminate sustainable curricula. It aims to evolve continuously alongside technological and social changes, fostering forward-thinking and future readiness in learners [63]. Essentially, SLE seeks to make education more continuous, flexible, and adaptable to meet diverse learner needs. The concept is exemplified in studies like Chen's findings, which show that e-learning in higher education provides lifelong, diverse learning opportunities, aligning with SLE objectives [64]. Azeiteiro, Bacelar, Caetano, and Caeiro found that e-learning for sustainable development in higher education is particularly effective for full-time employees [65]. Edelhauser and Lupu-Dima predicted significant changes in traditional education due to online course delivery, an effective strategy for sustainable education noted during the COVID-19 pandemic in Romanian higher education [66]. The flipped classroom is identified as a leading methodology in driving sustainable development, being a preferred teaching strategy [54,67], creating a beneficial and sustainable classroom ecology [68].

3. Materials and Methods

3.1. Participants and Research Context

This study involved 33 students from a national university in Northern Taiwan, all juniors in the mechanical and mechatronic engineering departments. The group comprised 27 males, 4 females, and 2 participants who preferred not to disclose their gender (refer to Table 1). Participation required enrollment in mandatory engineering courses. In line with the Bilingual Nation 2023 policy, the university promotes EMI courses, and these students were enrolled in a required engineering course delivered via the EMI model. In November 2023, an anonymous online questionnaire survey was conducted with all 33 participants. Details on their self-assessed English proficiency and duration of English usage are provided in Table 2, Table 3, and Table 4.

Table 1. Participants breakdown in terms of genders.

Genders	N	%
Male	27	82%
Female	4	12%
I prefer not to say.	2	6%
Total	33	100%

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Table 2. Participants' self-evaluation for English proficiency.

Levels of Proficiency	N	%
Very well	0	0%
Well	5	15%
Ok	24	73%
Poor	2	6%
Very poor	2	6%
Total	33	100%

Table 3. Participants' self-evaluation for English proficiency be good at speaking, writing, listening, and reading.

English Skills	N	%
Speaking	4	12%
Writing	2	6%
Listening	8	24%
Reading	19	58%
Total	33	100%

Table 4. Participants' length for English usage.

Length	N	%
0 minute	1	3%
1-30 minutes	17	52%
31-60 minutes	10	30%
61-90 minutes	1	3%
More than 91 minutes	4	12%
Total	33	100%

3.2. Procedure

The 33 participants were enrolled in a mandatory engineering course using the EMI model. The instructor implemented the flipped classroom approach, incorporating timely L1 support to facilitate learning in EMI. Recorded videos related to the course content were prepared and made available on an online teaching platform for pre-class preparation. In-class activities included problem-solving tasks and achievement tests. These tests, divided into pre-in-class and post-class assessments, evaluated students' learning performance. Upon completing the course, students participated in an online questionnaire to provide feedback on their experience.

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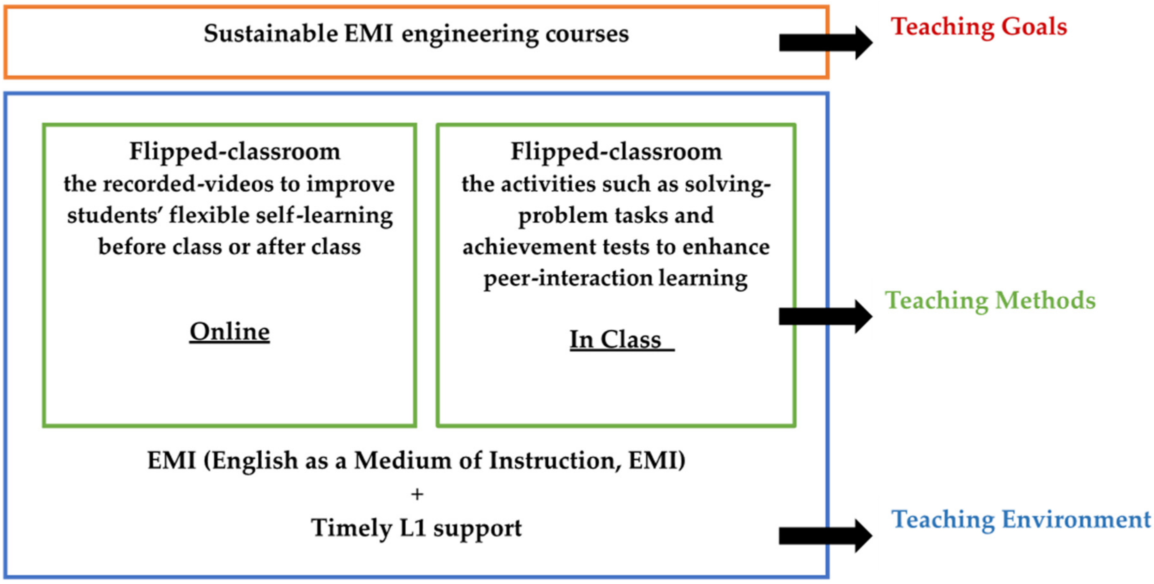

Figure 1. The structure and design of EMI engineering course.

3.3. Instrumentation

The questionnaire was developed based on AI-Zahrani's (2015) study on the impact of the flipped classroom through social learning platforms on higher education students' creative thinking, with Dr. AI-Zahrani's approval for its citation and use. Expert advice was sought to revise some items, and pilot testing was conducted. The questionnaire comprised four parts: background information, general views about flipped classrooms in engineering EMI courses, their impact on creativity, and the challenges encountered. Additionally, achievement tests evaluated participants' learning performance.

3.4. Data Collection and Analysis

A quantitative approach was employed for data collection and analysis. The questionnaire explored perceptions regarding flipped classrooms in engineering EMI courses, their role in promoting creativity, and their difficulties. Upon completion by 33 juniors from the mechanical and mechatronic engineering departments, the responses were analyzed using descriptive statistics. A chi-square test examined significant differences between participants' English usage duration and their perceptions of flipped classrooms. The achievement test results were also analyzed descriptively. Table 5 details the data collection and analysis methods used in this study.

Table 5. The Data Collection and Analysis in this Study.

Research Question	Instrument	Variable	Data Analysis
1. What are students' perceptions of the engineering EMI course when taught through a flipped classroom approach?	Questionnaire	1. students' general views about Flipped classroom via EMI (Q5-Q18) 2. the role of the Flipped classroom in the promotion of creativity (Q19-Q28) 3. Difficulties with the Flipped classroom (Q29-Q35)	1. Descriptive Statistics
2. How does students' English usage impact their learning experience using a flipped classroom model in engineering EMI course?	Questionnaire	1. students' background information (Q1-Q4) 2. students' general views about Flipped classroom via EMI (Q5-Q18) 3. the role of the Flipped classroom in the promotion of creativity (Q19-Q28) 4. Difficulties with the Flipped classroom (Q29-Q35)	1. Descriptive Statistics 2. Chi-square Test
3. How does this approach affect students' learning achievements?	The pre- and post- achievement tests		1. Descriptive Statistics

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4. Results

4.1. General Views about Flipped-classroom in Engineering EMI Course

Table 6 indicates that most students experienced a positive impact from the flipped classroom in their engineering EMI courses. Approximately 70% of the students favored the course's arrangement and design. Notably, 85% agreed, ' The flipped classroom helps me to participate in learning activities effectively.' These results suggest that the flipped classroom model significantly enhances students' learning effectiveness in these courses.

4.2. The Promotion of Creativity about Flipped-classroom in Engineering EMI Course

Table 7 shows that most students positively agreed that flipped classrooms in engineering EMI courses promote creativity. Notably, 80% concurred with two specific statements: 'The flipped classroom helps me to generate more flexible and applicable ideas' and 'The flipped classroom helps me to generate unusual ideas.' These findings suggest that the flipped classroom model significantly fosters students' creative abilities in their learning process.

4.3. Difficulities with Flipped-classroom in Engineering EMI Course

Table 8 indicates that most students encountered few difficulties with the flipped classroom curriculum model in engineering EMI courses. Generally, students experienced minimal challenges. However, two items elicited more agreement regarding difficulties: 'I was not adequately prepared to integrate the flipped classroom' and 'The flipped classroom required more work than traditional lectures.' These responses suggest that while the overall difficulty was low, specific aspects of the flipped classroom model presented more significant student challenges.

4.4. Significant differences among participants' length for English usages and all perceptions of flipped-classroom in engineering EMI course

The chi-square test results in Table 9 show significant differences in five items, correlating students' English usage duration with their perceptions of flipped classrooms in an engineering EMI course. Four items under 'General Views about Flipped-Classroom' demonstrate this correlation: 'The flipped classroom helps me to connect theory with practice in real life' ($\chi2=38.97$, df=12, p=0.000106), 'The flipped classroom facilitates more communication between me and my teacher' ($\chi2=40.48$, df=12, p=0.0000598), 'The flipped classroom enables me to manage my own learning activities' ($\chi2=24.68$, df=12, p=0.0164), and 'The flipped classroom facilitates more communication between me and my classmates' ($\chi2=35.57$, df=12, p=0.00038). These results suggest a relationship between students' daily English usage and their development of problem-solving skills and personalized learning in flipped classrooms. Additionally, under 'Promotion of Creativity,' the item 'The flipped classroom gives me the ability to analyze information to generate new ideas' ($\chi2=35.57$, df=12, p=0.00038) indicates a link between English usage and creative ideation in flipped classrooms.

Table 6. Participants' General Views about Flipped-classroom in Engineering EMI Course.

Items	N (%)					
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total
The flipped classroom offers me the opportunities to review the lectures as many times as I need.	0 (0%)	0 (0%)	6 (18%)	23 (70%)	4 (12%)	33 (100%)
The flipped classroom offers me the access to the online course tools and materials.	0 (0%)	0 (0%)	4 (12%)	16 (49%)	13 (39%)	33 (100%)
The flipped classroom helps me to use various e-learning resources.	0 (0%)	0 (0%)	5 (15%)	21 (64%)	7 (21%)	33 (100%)
The flipped classroom helps me to enrich my learning experience.	0 (0%)	0 (0%)	8 (24%)	19 (58%)	6 (18%)	33 (100%)
The flipped classroom helps me to connect theory with practice in real life.	0 (0%)	1 (3%)	13 (39%)	15 (46%)	4 (12%)	33 (100%)
The flipped classroom helps me to effectively cooperate with my classmates and Colleagues.	0 (0%)	0 (0%)	12 (36%)	15 (46%)	6 (18%)	33 (100%)
The flipped classroom facilitates more communication between me and my teacher.	0 (0%)	1 (3%)	6 (18%)	21 (64%)	5 (15%)	33 (100%)
The flipped classroom helps me to effectively participate in the learning activities.	0 (0%)	1 (3%)	4 (12%)	22 (67%)	6 (18%)	33 (100%)
The flipped classroom enables me to manage my own learning activities.	0 (0%)	1 (3%)	7 (21%)	21 (64%)	4 (12%)	33 (100%)
The flipped classroom helps me to develop my problem-solving skills.	0 (0%)	1 (3%)	6 (18%)	20 (61%)	6 (18%)	33 (100%)
The flipped classroom facilitates more communication between me and my classmates.	0 (0%)	1 (3%)	11 (33%)	17 (52%)	4 (12%)	33 (100%)
The flipped classroom is a very enjoyable approach.	0 (0%)	1 (3%)	6 (18%)	19 (58%)	7 (21%)	33 (100%)
I prefer the flipped classroom over the traditional lecture.	0 (0%)	1 (3%)	7 (21%)	17 (52%)	8 (24%)	33 (100%)
The flipped classroom facilitates my personalized learning.	0 (0%)	1 (3%)	8 (24%)	19 (58%)	5 (15%)	33 (100%)
Total	0 (0%)	9 (2%)	103 (22%)	265 (58%)	85 (18%)	462 (100%)

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Table 7. Participants' Promotion of Creativity about Flipped-classroom in Engineering EMI Course.

Items	N (%)					
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total
The flipped classroom helps me to think differently.	0 (0%)	0 (0%)	9 (27%)	19 (58%)	5 (15%)	33 (100%)
The flipped classroom helps me to generate more flexible and applicable ideas.	0 (0%)	0 (0%)	10 (30%)	19 (58%)	4 (12%)	33 (100%)
The flipped classroom helps me to generate unusual ideas.	0 (0%)	1 (3%)	9 (27%)	19 (58%)	4 (12%)	33 (100%)
The flipped classroom helps me to generate ideas that are contemporary and new.	0 (0%)	2 (6%)	10 (30%)	19 (58%)	2 (6%)	33 (100%)
The flipped classroom helps me to generate various and more ideas.	0 (0%)	2 (6%)	9 (27%)	19 (58%)	3 (9%)	33 (100%)
The flipped classroom offers me the opportunity to discuss and assess new ideas.	0 (0%)	0 (0%)	9 (27%)	19 (58%)	5 (15%)	33 (100%)
The flipped classroom helps me to think creatively about the problem's causes and effects.	0 (0%)	0 (0%)	8 (24%)	21 (64%)	4 (12%)	33 (100%)
The flipped classroom gives me the ability to analyze information to generate new ideas.	0 (0%)	1 (3%)	7 (21%)	22 (67%)	3 (9%)	33 (100%)
The flipped classroom helps me to analyze the problem's components and address them separately.	0 (0%)	0 (0%)	7 (21%)	22 (67%)	4 (12%)	33 (100%)
The flipped classroom helps me to think creatively about the effects of the problem and how to address them.	0 (0%)	1 (3%)	9 (27%)	20 (61%)	3 (9%)	33 (100%)
Total	0 (0%)	7 (2%)	87 (26%)	199 (61%)	37 (11%)	330 (100%)

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Table 8. Participants' Difficulties about Flipped-classroom in Engineering EMI Course.

Items	N (%)					
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total
I was not adequately prepared to integrate the flipped classroom.	2 (6%)	13 (40%)	14 (42%)	4 (12%)	0 (0%)	33 (100%)
The flipped classroom required more work than traditional lectures.	2 (6%)	11 (34%)	14 (42%)	6 (18%)	0 (0%)	33 (100%)
Course tools and materials were not sufficiently prepared.	5 (15%)	17 (52%)	8 (24%)	3 (9%)	0 (0%)	33 (100%)
Course objectives were not sufficiently clear to me.	5 (15%)	19 (58%)	7 (21%)	2 (6%)	0 (0%)	33 (100%)
I did not receive sufficient feedback during the in-class activities.	3 (9%)	18 (55%)	10 (30%)	2 (6%)	0 (0%)	33 (100%)
I lacked time to watch the video-recorded lectures and other course materials.	4 (12%)	15 (46%)	12 (36%)	2 (6%)	0 (0%)	33 (100%)
I had difficulties accessing the course online tools and materials.	5 (15%)	15(46%)	10 (30%)	3 (9%)	0 (0%)	33 (100%)
Total	26 (11%)	108 (47%)	75 (32%)	22 (10%)	0 (0%)	462 (100%)

Table 9. Significant differences among participants' length for English usages and all perceptions of flipped-classroom in engineering EMI course.

General Views about Flipped-classroom in Engineering EMI Course	**Chi-square Test**		
Items	$\chi2$	df	*p*
The flipped classroom helps me to connect theory with practice in real life.	38.97	12	0.000106*
The flipped classroom facilitates more communication between me and my teacher.	40.48	12	0.0000598*
The flipped classroom enables me to manage my own learning activities.	24.68	12	0.0164*
The flipped classroom facilitates more communication between me and my classmates.	35.57	12	0.00038*
The Promotion of Creativity about Flipped-classroom in Engineering EMI Course	**Chi-square Test**		
Items	$\chi2$	df	*p*
The flipped classroom gives me the ability to analyze information to generate new ideas.	35.57	12	0.00038*

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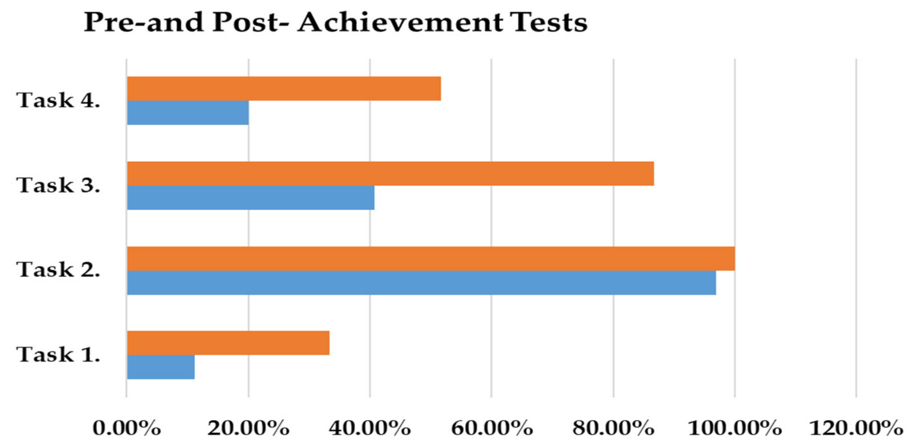
4.5. Pre-and post-achievement tests of flipped-classroom in engineering EMI course

Figure 2 illustrates that students' learning outcomes were positively impacted by participating in the flipped classroom in an engineering EMI course. Pre- and post-achievement tests effectively evaluated students' learning outcomes and assessed their comprehension of the course material. These tests clearly indicate the flipped classroom's effectiveness in enhancing students' understanding and mastery of the course content.



	Task 1.	Task 2.	Task 3.	Task 4.
Results of Post-achievement Test Number of Respond with the Correct Answers %	33.33%	100%	86.67%	51.61%
Results of Pre-achievement Test Number of Respond with the Correct Answers %	11.11%	96.88%	40.74%	20%

Figure 2. The results of pre-and post- achievement tests.

5. Conclusions and Implications

This study provides empirical evidence of the effectiveness of the flipped classroom model in EMI engineering courses for EFL students. It highlights the positive impact on students' engagement, creativity, and learning outcomes. It demonstrates how this approach helps students connect theory with practical application, improve communication skills, and manage their learning activities more effectively. The integration of L1 support is vital in facilitating student comprehension and participation in EMI contexts.

These findings suggest that flipped classrooms and L1 support are an effective pedagogical strategy in EMI settings, especially in engineering education, where the practical application of theoretical knowledge is critical. This study offers insights for educators in designing future EMI courses to cater to diverse student needs, incorporating innovative teaching methods and technologies. It also opens avenues for further research into individual differences in learning styles and strategies among students in EMI courses, enhancing the development of more learner-centered and effective educational models.

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