International Journal of Learning, Teaching and Educational Research
Vol. 23, No. 4, pp. 99-117, April 2024
https://doi.org/10.26803/ijlter.23.4.6
Received Feb 21, 2024; Revised Apr 11, 2024; Accepted Apr 17, 2024

Bridging Content and Language in English-medium Engineering Programs

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Abstract. English-medium Instruction (EMI) is increasingly being implemented in diverse educational settings where English is not the primary language. However, a persistent challenge of EMI implementation lies in the scarcity of high-quality EMI teaching materials that effectively enhance both content knowledge and language acquisition. This study aimed to investigate how language is integrated with content in EMI lessons and to assess their efficacy. The study involved three Civil Engineering teachers, three language teachers, and 102 students. Data collection instruments comprised journals kept by content and language teachers during the EMI materials development process, pre-tests and post-tests, satisfaction surveys, and semi-structured interviews. The quantitative results were analyzed using descriptive statistics and t-tests, while content analysis was used to analyze qualitative data. Results revealed that students expressed high satisfaction with the materials, noting increased participation in EMI classes, enhanced content comprehension, and heightened awareness of language use in lessons. Nonetheless, the design process of EMI materials is intricate, non-linear, time-consuming, and demanding of pedagogical expertise. While collaborative efforts between content and language teachers have appeared promising in theory, practical implementation in real contexts has proven to be challenging. It is recommended that the EMI materials developers possess pedagogical knowledge on content and language teaching, recognize the iterative and complex nature of the material design process, and the need for ongoing communication with the respective to enhance the success of the collaboration.

Keywords: English-medium instruction; engineering; content and language integrated materials

1. Introduction

In the present globalized world, English has established itself as the predominant medium of communication. Its influence extends to various domains, including

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the realm of education - serving as a crucial pathway for individuals to attain their goals and pursue their desired careers. As English has gained prominence as a widely accepted language in the world, it has significantly impacted the field of instruction in non-English speaking countries (see Baker, 2021; Bowles & Murphy; 2020; Chapple, 2015; Galloway et al., 2020; Hultgren et al., 2015). Not limited to the compulsory education sector, but also kindergarten, vocational, and professional education, the number of courses integrating content and language has increased significantly (Coyle, 2007). Moreover, the push for internationalization in higher education has resulted in an increase in English-taught programs, especially in engineering and business fields, making institutions more competitive. Several colleges in many non-native English-speaking countries use EMI to teach engineering disciplines at the undergraduate level since English is the language of science and technology in the 21st century (Crystal, 2012). Moreover, it is undeniable that a sizable portion of teaching resources and materials used in educational contexts are currently available in English. Furthermore, careerwise, international engineering companies demand English-proficient engineers. Such factors support Macaro's (2015) assertion that EMI is an 'unstoppable train' (p.7) because, theoretically, English's worldwide dominance pushes its use in education, while practically, institutions see its competitive advantages as well as the inherent access to resources it provides, fuelling its growth.

As EMI in higher education is an unstoppable trend, it is crucial to consider how students perceive, believe in, comprehend, and express satisfaction with this policy. Students' perspectives on EMI across various countries reveal a complex blend of appreciation and concern (see Albraki, 2017; Ekoç, 2020; Gu & Ren, 2016; Kim et al., 2017; Poosinghar & Chaiyasuk, 2022; Pun & Jin, 2021). Students generally recognize the practical benefits of EMI, such as improved employment opportunities and enhanced global competitiveness (Albraki, 2017; Kim et al., 2017). However, they also express challenges, particularly those with lower English proficiency who face difficulties in understanding technical content and experience psychological distress (Gu & Ren, 2016; Ekoç, 2020). Despite these challenges, there is a prevailing belief that EMI should continue, albeit with policy modifications to better support students' language needs and learning experiences (Pun & Jin, 2021). This mixed reception highlights the critical need for balanced EMI approaches that reflect the necessity of collaboration between content and language teachers.

Meanwhile, teachers' perspectives on EMI reveal diverse views and challenges (Aguilar, 2017; Almusharaf et al., 2023; Başıbek et al., 2014; Macaro & Han, 2020). In Turkey, Başıbek et al. (2014) found that lecturers generally view EMI positively, believing it enhances students' academic and professional prospects, yet they also recognize the need for improved training and support, especially for those less proficient in English. Aguilar's study in Spain showed a preference among instructors for EMI, perceiving it as beneficial for career advancement, though it also points to a lack of reflection on EMI teaching practices. In South Korea, Almusharaf et al. (2023) reported high self-confidence among instructors in delivering EMI courses, suggesting a comfortable and competent approach to

English-medium teaching. Contrastingly, Macaro and Han's (2020) research in China highlighted the challenges due to the lack of priority given to EMI certification and professional development, emphasizing the need for subject-specific instructional skills in addition to English proficiency. These insights collectively underscore the complexities involved in EMI implementation and the importance of addressing the professional development needs of teachers in EMI environments.

Several authors addressed the challenge of selecting and adapting appropriate teaching materials from content and language integrated programs (Bovellan, 2014; Nikula, 2008). They stressed the importance of high-quality materials tailored to local needs and suitable for specific student targets. The adaptation of materials, such as textbooks, is crucial to avoid misunderstandings of subject matter and to maximize learning potential. Mahan's (2022) study added depth to the discussion by examining scaffolding strategies. The study found differences in how social sciences and natural sciences are taught, with natural sciences offering more contextual cues and support materials. This suggests the need for more specialized learning activities and support in disciplines with fewer available materials.

Arnó-Macià and Mancho-Barés (2015) emphasized the importance of a well-structured teaching plan that progressively uses English as the medium of instruction. Their recommendations focus on catering to students' language proficiency levels, providing language support, and balancing language and content systematically. They highlighted the need for clear policies on integrating language and content and developing students' language skills. In terms of EMI learning materials, Ball (2018) suggested that teaching materials in content and language integrated contexts should highlight content, cognition, autonomy, and cooperative learning. Herein, the learners should have the chance to use graphic organizers as well as information and communication technologies (ICT). Thus Ball (2018) draws a set of material principles that cater to language as a meaning-making system that provides learners a chance to become operative in a content and language integrated learning environment.

Banegas and Busleiman (2021) also claimed that it is important to create teaching materials developed in a context-responsive manner, considering the specific news and interests of the learners. The materials also should include activities that develop learners' language awareness, not only in terms of specific vocabulary but also in terms of textual grammar. It is also noteworthy that the materials accommodate the needs of EMI learners and provide proper scaffolding for both content learning and language learning. In terms of activities, the materials should incorporate a focus on tasks and engagement, providing varied and interactive activities to maximize input and learner participation. In addition to that, the materials used in the EMI context should promote autonomous learning, allowing learners to explore and manipulate tools and resources (see Ball, 2018). Learning materials should be learner-centered and relevant to future contexts. Lastly, the materials should provide opportunities for detailed feedback on both language and content aspects and should support collaborative work among learners.

The design of the EMI Engineering lesson in this study was grounded in the 4C principles of Content and Language Integrated Learning (CLIL): content, communication, cognition, and culture (Coyle, 2015). The integration of the language and content of engineering was guided by these principles, which facilitated effective communication, cognitive engagement, and knowledge construction. Furthermore, cultural elements were incorporated through group work-based activities. An interactive learning environment was created by incorporating tasks that required students to solve problems and apply critical thinking skills. This promoted active participation and collaborative study among the students.

The above studies collectively underscore the importance of a holistic approach to language and content integration in EMI and similar educational models. They call for thoughtful planning, careful selection and adaptation of materials, and specific strategies to support students' learning, thereby enhancing the overall effectiveness of these instructional approaches. This study aimed to delve into how language and content teachers collaboratively design lesson plans that effectively integrate language learning with engineering content. The focus would be on understanding the process developed in this collaborative effort. Additionally, it gauges how students perceive and respond to newly designed EMI lessons. Thus, two questions are sought in the study: (1) How are EMI Engineering lessons designed collaboratively? (2) To what extent is the lesson effective?

2. Methodology

2.1 Research Design

The research adopted mixed-methods by using convergent parallel design, where the qualitative and quantitative data were collected and analyzed independently, but the results were interpreted together (Creswell & Pablo-Clark, 2011; Guest and Fleming, 2014). The qualitative method was used to answer research question one and the quantitative method was employed to answer research question two. Combining qualitative and quantitative results allows researchers to obtain broad perspectives on the complexity of a phenomenon that may be disregarded when employing just one research approach (McKim, 2017).

2.2 Participants

The participants included three engineering lecturers, three language teachers, and 102 engineering students. The three Civil Engineering lecturers (content teachers) drawn from a Thai EMI context voluntarily participated in this study. They all taught EMI engineering courses and possessed varied lengths of teaching experience, ranging from three to seven years. Apart from engineering lecturers, language teachers and students were also selected to participate. The study involved three language teacher experts in teaching English as a foreign language (EFL) and had broad experiences in teaching materials design. They collaborated closely with engineering lecturers to develop and implement lesson plans that integrated content and language learning in the EMI engineering classes. In the case of the student participants, there were 102 engineering undergraduates who

were currently enrolled in various engineering programs at the Thai university. Among the total, only thirty students were pursuing EMI courses for Civil Engineering. The students' English skill levels ranged from A1 to C2, as defined by the Common European Framework of Reference for Languages (CEFR) (Council of Europe, 2001).

2.3 Research instruments

Corpus tool

Course teaching materials and related documents about dry friction, such as PDF lesson files and PowerPoint slides, were analyzed by a corpus tool, namely AntConc, to gain insights into vocabulary types (e.g., academic terminology, jargon, general words), as well as information on sentence structures and grammar frequently encountered in study materials. The result of this corpus analysis was utilized for developing English-integrated engineering lessons on dry friction to use in EMI classes. The final word list was confirmed by the content teachers and engineering students.

EMI Engineering lesson

A two-part EMI engineering lesson entitled "Dry friction" was designed by content and language teachers. It was composed of four main learning outcomes: content, communication, cognition, and culture. Each lesson started with pre-teaching, which aimed to prepare learners with vocabulary knowledge regarding dry friction. This was followed by teaching which required students to read and do activities fostering cognition skills in solving content-related problems. Group work activities were used to encourage students' collaboration and active participation. For post teaching, students were asked to solve problems concerning the content learned. In the materials, figures and illustrations were used to facilitate content comprehension. Problem-solving tasks were used to enhance communication and cognition, while language tasks, such as fill in the blank exercises and word puzzles, were integrated to enhance language proficiency. This lesson was piloted with engineering students and revised by the content teachers before using in the real study.

Language and content teacher journals

During the process of corpus-based language and content-integrated material development, both content and language teachers kept unstructured journals after each meeting. They were expected to write their experiences and perceptions relating to the materials development process.

Pre-test and post-test

The pre-test and post-test, consisting of fifteen multiple-choice items, were developed and verified by content teachers to align with the topics covered in the EMI engineering lesson (Dry friction). Then, the language used in the test was checked by the language teachers to ensure accuracy and clarity. The pre-test was conducted to evaluate students' proficiency in engineering and language, while the post-test was employed to assess the progress made by students in their engineering and language skills after completing the EMI engineering lesson. Both tests were identical.

Satisfaction survey

A four-point Likert scale satisfaction survey was developed by the researchers. It composed of nine questions relating to the quality of teaching, the teacher's expertise and familiarity with the subject matter, the efficacy of the teaching aids, the appropriateness of the content taught, the level of content learned, the comprehensibility of the lesson, the opportunity for collaborative work, the use of English as the medium of instruction, and overall satisfaction. The survey was verified by the three researchers before distributing to students.

Semi-structured interviews

To follow up the satisfaction survey about the EMI engineering lesson, semi-structured interviews were conducted to explore deeper insight about students' experiences and perceptions of the EMI engineering lesson. Five interview questions were given to three researchers for validation. The interview lasted about thirty minutes for each participant. They were informed that their responses were voluntary and would be kept confidential.

2.4 Ethical approval

This study was approved by the Human Research Ethics Committee. Every participant was given the informed consent and signed voluntarily. After that, their information was kept confidential, and they were allowed to withdraw from the research study if they wanted to.

3. Data collection and data analysis

Table 1 below shows the process of data collection and data analysis based on the 5 main steps of the study.

Table 1: Data collection and analysis

Data collection process	Instrument	Data analysis
Step 1 Corpus-based analysis of text		
- Analyze teaching materials by using AntConc	- List of highly frequent academic words, terminologies, and grammatical structures	- AntConc program
- Confirm the word list	- Final lists of selected academic words, terminologies, and salient grammar aspects.	- Frequency count - Final word selection by content teachers and students
Step 2 Lesson design		
- Collaboratively design two lessons	- Journals recorded by language and content teachers	- Content analysis
Step 3 Lesson delivery		
-Deliver the lessons	Before class: - Pre-test After class: - Post-test after studying - Satisfaction survey after studying	- Descriptive analysis (Percentage); T-test - Content analysis

	- Semi-structured interview	
Step 4 Sharing insights and Joint revision of the lesson		
- Discuss the strengths and weaknesses of the lessons	- Semi-structured interview with content teachers	Content analysis

The data collection process was divided into four major steps based on the process of EMI materials development as displayed in Table 1. For data analysis, the quantitative data from the pretest, post-test, and survey responses were analyzed by using descriptive statistics and T-tests. In the realm of qualitative analysis, content analysis was applied to explore insights emerging from the semi-structured interviews.

4. Results

4.1 Designing EMI engineering lessons collaboratively

Figure 1 presents a systematic approach in collaboratively designing the EMI Engineering lessons. Language learning and content instruction are integrated, emphasizing collaboration between language and content teachers (Engineering lecturers) to enhance the overall educational experience for students.

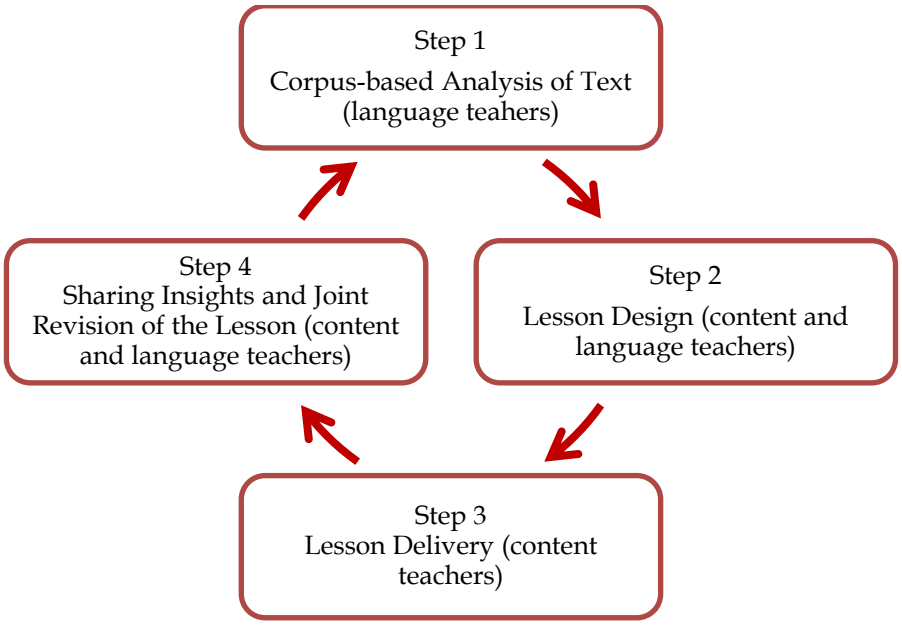

Figure 1: EMI engineering lesson design process

Figure 1 illustrates a collaborative process between language teachers and content teachers (Engineering lecturers) in designing a lesson, indicating a step-by-step interaction between the two roles. This process was verified by content and language teachers:

Step 1 Corpus-based Analysis of Text – Responsibities of Language Teachers: The process started with language teachers performing a corpus-based analysis of the text. This involved examining the language used in the subject material and

identifying key linguistic features, such as vocabulary, grammar, and usage patterns, that are relevant to the lesson.

Step 2 Lesson Design – Responsibilities of Language and Content Teachers: Next, both language teachers and content teachers worked together to define the objectives of the lesson. These objectives were likely to encompass both content-related goals and language acquisition targets, ensuring that students not only grasped the subject matter but also improved their language skills.

Step 3 Lesson Delivery – Responsibilities of Content Teachers: The content teachers took the lead in delivering the lesson. They used the insights from the corpus-based analysis to inform their teaching, making sure that the delivery was tailored to the linguistic level of the students while covering the necessary content. As the lesson was delivered, both language and content teachers were involved in monitoring participation. They observed how students interact with the material and each other, paying attention to both content understanding and language use.

Step 4 Sharing Insights and Joint Revision of the Lesson – Responsibilities of Language and Content Teachers: Finally, after the lesson was delivered, both sets of teachers jointly reviewed and revised the lesson plan. This step ensured that future lessons were improved based on feedback and observations, further aligning content delivery with language development goals.

This flowchart suggests a dynamic and iterative process where both sets of teachers worked closely throughout the instructional cycle, from planning to delivery to revision, ensuring that content instruction was linguistically accessible, and that language instruction was content-relevant.

Further findings elicited from the content analysis of journals and teacher interviews revealed the challenges found during materials designing and development. During stage 1, which was about the corpus-based analysis of text, both language and content teachers mentioned that they did not know the students' background in both physics content and language proficiency. So, it was difficult for them to select the appropriate language points. In addition, for this step, language teachers further reported that most vocabulary and terminologies were unfamiliar to them and the concepts in the reading texts were complex for students to understand. As a result, it was rather difficult to design the materials based on unfamiliar content, so it is unavoidable that language teachers had to become familiar with the content. Excerpt below is quoted relevance to support this claim.

> *"What's very challenging for me is the technical terminology. When I read the content teacher's guide and presentation, I observed that friction involves technical terms and concepts that can be complex for students to understand. As a language teacher, I'm not familiar with those technical terms, thus it's time consuming to integrate these technical terms effectively into the lesson plan; it required careful consideration of students' content and language proficiency levels and finding appropriate*

> *ways to introduce and explain the vocabulary."* Extract 1 (Language Teacher Journal)

To cope with the challenges above, the material developers decided to use AntConc, a corpus tool to make a list of words related to the topics. They then asked content teachers to primarily screen first, and then ask students to confirm the unfamiliar words.

During the lesson design process, further data revealed that the content teachers and language teachers had different viewpoints on the proportion of language and content needed due to the time constraints of lessons. For instance, the content teachers thought that (1) group work activities were interesting but they took too long (2) subject matters were the main content that the students had to acquire at the end of the class and language was only a by-product (3) they were not sure about how to integrate language in the lessons and design language activities, and they did not know how to teach language. Meanwhile, language teachers thought that (1) there were limited resources available to find examples of well-designed CLIL lesson plan models with specific requirements, so it was not easy to design the materials that achieved two goals at the same time (2) the language teachers did not truly understand the content of engineering (see extract below).

> *"I faced challenges in combining mathematical equations and language phrases in my CLIL lesson plan due to my limited familiarity with the mathematical equations and overall content. As a language teacher, venturing into unfamiliar territory can be daunting, making it difficult to integrate complex mathematical concepts seamlessly into the language instruction. I may have limited exposure to or knowledge of mathematical equations. This lack of familiarity can hinder my ability to understand the equations fully, explain clearly, and guide students effectively. In addition, teaching content subjects like mathematics requires a solid understanding of the underlying concepts. In this case, not having a strong background in the content related to the mathematical equations makes it challenging for me to design meaningful activities or provide accurate explanations."* Extract 2 (Language Teacher Journal)

Other thoughts included 'time consuming' preparation for each process, which added more pressure and difficulty in setting collaborative meetings because both parties are busy. In addition, designing a lesson for a mixed proficiency group is hard. So, activities that required collaboration between the high and low proficiency students were proposed. Choices of activities were given to the content teachers so they could choose the ones that were suitable for their teaching styles as depicted in the excerpt below.

> *"I have encountered challenges in designing activities for the content and language integrated lesson plan on friction due to the need to consider the difficulty of the activities and the students' content and language proficiency levels. As I supposed, creating activities that strike the right balance between challenge and appropriateness for students' abilities is complex for me. It was challenging for me to determine the appropriate level of difficulty for the activities related to friction. If the activities that I will create are too easy, students may become disengaged, while overly*

> *complex activities may discourage and frustrate them. So, it took me a long time to decide the right balance to ensure optimal learning and engagement."* Extract 3 (Language Teacher Journal)

However, both teachers agreed that figures and illustrations are important to include in the lesson when dealing with complex concepts.

> "*The figure is from the textbook or the concept of the engineering, the real engineering. So, I mean the context is very hard already and it's complicated. So, if we find something that the student can see easily in the classroom …, it's just a simple thing with an explanation that the student might have experienced already. So, I think it can help them."* Extract 4 (Semi-structured interview)

In terms of assessment, there was not enough time for the lessons when the goals of language learning were emphasized. Also, it was not easy to create assessments that accurately measure their understanding and progress.

> "*The pre-test and post-test should be tailored to their abilities to provide meaningful data. Also, incorporating appropriate language demands, such as vocabulary, sentence structure, and comprehension, alongside assessing their understanding of friction-related concepts, requires my careful consideration."* Extract 5 (Semi-structured interview)

To solve this problem, consultations with the content teachers were done to check the mathematical equations which had been integrated with language, so there would be no problems with the in-class execution regarding these equations. Due to the diverse proficiency of students, more activities were provided for content teachers. This way they could select and use extra activities on a supplementary basis when there was adequate time for some groups of students.

At the delivery stage, the lessons were delivered to students smoothly. The content teacher followed every step and most of the students actively participated. Activities included doing pair work, group work, and giving presentations in front of the class. The content teacher gave feedback to the students, and this demonstrated that the students understood the lessons. Classes were not silent, and they enjoyed discussing their tasks with the group. After giving the lessons, the content teachers admitted that (1) they felt reluctant to use collaborative activities because they usually lectured rather than doing activities and it took much time to complete the lesson, (2) content teachers took more time for lesson preparation and lesson delivery.

At the last stage, the content and language teachers met after the class and discussed the content of the EMI lessons. They agreed that challenges are caused by (1) inadequate knowledge about students' language and content background, (2) the silent classroom atmosphere, (3) low math or physics background, (4) inadequate knowledge about how to assess the students' understanding of content and specific language use, and (5) limited time allocation for the lesson. During the process of designing and developing the EMI lessons, conflicts between language and content teachers were not avoided. Common disagreements involved the use of definitions of key terms – the content teacher

thought that giving only definitions does not help with understanding while the language teacher thought this kind of exercise may help reading and vocabulary learning and increase exposure to language in use. For example, when talking about introducing the history of friction, the content teacher felt this was information the students could find themselves if they were interested. In contrast, language teachers found that this extra reading passage could help improve reading skills. Quoted below was the excerpt from teacher interview.

- *"To engineer students, the definition is just the term or the sentence, the phrase of the statement. But if you understand the concept, right, I think you don't have to remember. …all of the text in that sentence...if you understand the concept, it can help you"* Extract 6 (Semi-structured interview)

However, despite of some conflicting ideas between the two groups, both the content and language teachers agreed on the following points: (1) Language (English) is the barrier to content understanding; (2) Having pre-teaching activities for language preparation is helpful; (3) Figures and illustrations are needed to simplify the content difficulty.

4.2 EMI Lesson Effectiveness

The effectiveness of the collaborative EMI lesson design model was sourced from the **(1)** Satisfaction survey from the seventy-two students, (2) the Pre**-** and Post**-**tests results, and (3) Semi-structured interviews from the thirty students.

The satisfaction survey shown in Table 2 indicated the nine aspects that were measured including the quality of teaching, the teacher's expertise and familiarity with the subject matter, the efficacy of the teaching aids, the appropriateness of the content taught, the level of content learned, the comprehensibility of the lesson, the opportunity for collaborative work, the use of English as the medium of instruction, and overall satisfaction.

Table 2: Satisfaction survey

Aspect	Very dissatisfied	Dissatisfied	Satisfied	Very satisfied	M	SD
Quality of teaching	3% (2)*	6% (4)	35% (25)	57% (41)	3.46	0.73
Teacher's level of expertise and familiarity with the subject matter	1% (1)	8% (6)	26% (19)	64% (46)	3.53	0.71
Efficacy of the teaching aids employed in the lesson	0% (0)	11% (8)	50% (36)	39% (28)	3.28	0.65
Appropriateness of the content taught	1% (1)	6% (4)	56% (40)	38% (27)	3.29	0.64
Appropriateness of the level of content learned in the lesson	3% (2)	15% (11)	28% (20)	54% (39)	3.33	0.84

Comprehensibility of the lesson taught	3% (2)	24% (17)	49% (35)	25% (18)	2.96	0.78
Opportunity to work collaboratively with peers	1% (1)	24% (17)	49% (35)	26% (19)	3	0.75
Use of English as the medium of instruction	4% (3)	10% (7)	42% (30)	44% (32)	3.26	0.80
Overall satisfaction toward the lesson	0% (0)	4% (3)	58% (42)	38% (27)	3.33	0.56
					3.27	0.09

* Number of participants

The results suggested a generally positive reception towards various aspects of the educational experience. The quality of teaching and the teacher's level of expertise were particularly well-regarded, with most responses leaning towards satisfied and very satisfied, indicating strong approval of the instructors' capabilities and teaching methods. The use of teaching aids and the appropriateness of the content were also viewed favorably. The level of content and its comprehensibility present areas with mixed feedback, where a significant number of respondents express satisfaction, yet there's a noticeable portion that finds the lesson either too advanced or challenging to understand. This suggests room for improvement in aligning the content's difficulty with students' capabilities and in enhancing clarity in teaching. Collaborative opportunities and the use of English as the instruction medium showed a balanced distribution of opinions, with a slight inclination towards satisfaction. However, there were a considerable number of participants who were less enthusiastic about these aspects, indicating potential challenges in fostering effective group work and in the implementation of English as the teaching language. Overall satisfaction with the lesson was predominantly positive, demonstrating that despite certain areas for enhancement, the educational experience was well-received by the majority. This general contentment points towards a successful teaching approach, although areas were identified that could benefit from further attention to elevate the learning experience.

At the end of the survey, the open-ended question elicited students' insights about the lesson. Some students suggested integrating Thai language alongside English for instruction. The overall sentiment towards the quality of teaching is positive, with comments like "*The quality of teaching is good,*" "*Everything is good,*" *and* "*This is a good lesson*." A few students indicated areas for improvement in teaching materials. For instance, there was one suggestion to include 3D models, such as the Clip 3D model, for enhanced learning. Students also mentioned vocabulary challenges, indicating that some students may not be familiar with specific words used during the lessons. While some students did express difficulty with English, the use of visual aids like pictures helped in understanding the content. One detailed feedback from a student emphasized the importance of effective teaching methods. While acknowledging the expertise of many professors, the student believed that there was room for improvement on how content was conveyed. They went on to emphasize that visual demonstrations in some subjects are deemed necessary.

Table 3: Pre- and post-test results

Item	Pre-test (M, SD)	Post-test (M, SD)
1	74.29, 0.43	70.00, 0.45
2	5.72, 0.24	14.29, 0.36
3	35.71, 0.49	32.86, 0.48
4	57.14, 0.50	62.86, 0.48
5	75.71, 0.42	84.29, 0.48
6	84.29, 0.34	90.00, 0.26
7	67.14, 0.47	75.71, 0.42
8	55.71, 0.50	80.00, 0.38
9	74.29, 0.43	85.71, 0.32
10	62.86, 0.48	81.43, 0.37
11	37.14, 0.49	30.00, 0.47
12	35.71, 0.49	38.57, 0.49
13	24.29, 0.44	35.71, 0.49
14	22.86, 0.43	41.43, 0.50
15	32.43, 0.47	35.71, 0.49
	49.68, 0.44	57.23, 0.40

Results from the pre**-** and post**-**tests were presented in Table 3**.** The table illustrates an overall trend of improvement from pre-test to post-test across most questions. Initial scores were lower, and there was a significant increase in post-test scores, indicating that the subject matter was better understood after intervention or teaching. A paired-sample t-test was conducted to compare the means of pre- and post-test and a significant difference in the pre-test (M = 49.68, SD = 0.44) and post-test (M = 57.23, SD = 0.40); $t(14) = 3.3499$, p = .00 was found.

From student interviews, students expressed their satisfaction with the integration of language learning and content mastery, appreciating the use of instructional media and teacher support to understand new vocabulary. Despite this, they encountered challenges with unfamiliar words. Still, the use of visual aids and the focus on both language and subject matter by the same teacher helped to enhance their EMI learning experience.

> *"I am satisfied because the teacher used instructional media to make me understand the topic taught."* Extract 7

> *"I am satisfied because I study the subject in English and I am able to learn new vocabulary from the lessons. There are many unfamiliar words that I don't know."* Extract 8

> *"I am satisfied because many specific words are found in the lessons that are new to me. I can't translate the words but the teacher helps me to understand it using figures and illustration."* Extract 9

> *"I am satisfied because I learn both content and language from the same teacher."* Extract 10

5. Discussion

Findings showed that the collaborative design of EMI engineering lessons is a systematic and iterative process. In this study, language teachers began by analyzing texts for key linguistic elements, which then informed the joint lesson design with content teachers. The lessons, delivered by content teachers, were revised post-delivery through insights shared by both language and content teachers. Though the content and language integration sounded promising, training and support are needed as the process of material designing remained challenging (see Başıbek et al., 2014). During the process of designing the instructional materials, disagreements between the content and language teachers arose, but still they worked smoothly until the end. For instance, both groups of teachers agreed on the usefulness of figures and illustrations for complex concepts, yet they faced constraints of time and assessment design. Additionally, they sometimes disagreed on the inclusion of certain content, such as historical context. Specifically, content teachers usually prioritized subject matter and content coverage, while language teachers emphasized more on language proficiency development and pedagogical strategies. Both content teachers and language teachers had teaching and researching routines and other responsibilities, therefore they were busy. As a result, it was difficult to devote sufficient attention to collaborative materials design efforts. Regardless of difficulties, such collaborative efforts resulted in contextualized teaching materials (Bovellan, 2014; Nikula, 2008).

It can be implied that when both teachers work together, they could (1) finalize the list of language and content items to be addressed (2) define the balance between the two aspects within a limited time frame (3) possess the required knowledge, as it is necessary for language teachers to grasp the subject matter and for content teachers to have pedagogical knowledge. Both must have a similar mindset regarding the learner-centered approach. (4) define the objective and outcomes of lessons and each step (5) select the appropriate activities that facilitate students mastery of both language and content (6) assess their understanding through outcomes.

Further insights from students and teachers reported challenges arising from a lack of knowledge about students' backgrounds in content and language proficiency, unfamiliarity with technical vocabulary, and differing views on the balance of language and content within the lessons. These challenges persist as seen from the previous literature (Albraki, 2017; Ekoç, 2020; Gu & Ren, 2016; Kim et al., 2017; Poosinghar & Chaiyasuk, 2022; Pun & Jin, 2021). Despite the challenges, the satisfaction survey showed positive feedback across several educational aspects, with the highest commendations for teaching quality and instructors' subject matter expertise. Teaching aids and content appropriateness also received favorable ratings, suggesting that the tools and materials used were largely effective like in previous studies (Albraki, 2017; Ekoç, 2020). These students recognized the benefits of English-medium instruction. The pre- and post-test comparisons revealed a significant improvement in students' understanding post-intervention, evidenced by a statistical analysis showing higher mean scores in the post-test. However, there are indications that the level

of content difficulty and the comprehensibility of lessons may require adjustment to better suit student capabilities, which is in line with Pun and Jin's (2021) recommendation.

Perhaps it is important to note that students appreciated the instructional media and support provided by teachers to navigate new vocabulary and concepts, despite challenges with unfamiliar terminology. In line with Ball's (2018) findings, the use of visual aids was highlighted as beneficial in aiding comprehension and learning from a content teacher who could seamlessly integrate content and language instruction was seen as advantageous. The collective data suggested that the collaborative lesson plan design model was effective in enhancing students' subject understanding and language skills. To further improve the model, it may be beneficial to consider integrating native language support, employing more diverse and interactive teaching materials such as 3D models, and continuing to refine the balance between language and content instruction. Additionally, attention should be given to ensuring that the content is appropriately challenging and comprehensible for all students, potentially through differentiated instruction strategies.

The need to address the appropriacy of materials was necessary. Thus, when designing materials, the following were suggested, as the design process was inherently complex, nonlinear, and time consuming due to several possible factors.

The first factor that should be taken into consideration is the appropriate and balanced integration of language and content. Integration of language and content effectively requires careful consideration of pedagogical knowledge and subject matter expertise. Thus, designing a task that helps attain two goals within a limited time for each topic is extremely challenging (Mehisto, 2012). It is iterative and requires multiple revisions because most decisions to maintain the proportion of content and language are dependent on ensuring both sets of objectives are adequately addressed. Thus, the content and language integrated materials design and development process are time-consuming in practice and this needs to be acknowledged and accepted. In addition, the lesson should be customized for different students' backgrounds. Another point that needs careful consideration is that the content and language integrated materials were designed based on the student's background in both content and language knowledge to lessen the cognitive burden when dealing with both the content and language integrated content. Thus, knowing the students' existing knowledge can decrease problems in materials selection and activity design and serves the diverse needs of learners with varying language proficiency levels and subject matter knowledge. Since exercises should be accessible and engaging for all learners, the difficulty of content and language use should be carefully graded and choices should be provided.

In this study, the complexities of integrating content and language instruction underscored the need for careful planning and collaboration between content and language teachers. Effective integration requires the careful examination of

factors, such as curriculum alignment and instructional strategies to foster proficiency in both language and subject matter. Successful collaboration relies on clear communication and a shared educational goal, emphasizing the significance of sustained support systems. To overcome these problems and invest in comprehensive planning, educational institutions can enhance the overall educational experience for all students by developing high-quality learning materials.

6. Conclusion

Since language ability has been claimed to be an important barrier in English Medium Instruction (EMI) classes, preparing learning materials that have been adapted with language considerations are considered advantageous. However, there exists a gap in research regarding the design of such materials. Consequently, this study pursued two objectives. First, it sought to investigate the design and development of integrated language and content materials for EMI engineering classes which were achieved through collaboration between content and language teachers. Second, it aimed to evaluate the effectiveness of these materials. The developmental process included four stages: corpus analysis, lesson design, lesson delivery, and the sharing of insights culminating in joint revisions. The AntConc corpus analysis tool, content and language teachers' journals, pre- and post-tests, satisfaction surveys, and semi-structured interviews were employed to collect data from three content and three language teachers and 102 students. The findings revealed significant differences between the students' pre-test and post-test scores. Their high satisfaction with the integrated materials highlighted the efficacy of language preparation for enhancing content comprehension. Furthermore, the preference for group activities over traditional lecturing was evident, leading to the learning experience being more engaging. Respondants also suggested using figures, illustrations, and multimedia resources to increase the comprehensibility of complex engineering content. Despite the favourable learning outcomes, the joint design process of content and language integrated materials reflected several complexities, such as time constraints, and the balance of content and language modifications to include in the materials. The study recommends that EMI materials developers possess extensive pedagogical knowledge on content and language teaching to achieve the delicate balance between content and language objectives that optimize the dual learning outcomes. Knowing the students' background knowledge is also helpful for content selection. It is crucial to acknowledge these inherent complexities and manage them from the outset of the process.

Acknowledgment

This work was supported by Suranaree University of Technology (SUT), Thailand Science Research and Innovation (TSRI), and the National Science, Research and Innovation Fund (NSRF) (NRIIS number 179263).

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