Enhancing Science Vocabulary and Content Knowledge of Thai EFL students through Content and Language Integrated Learning (CLIL) and English Science Textbooks Word Lists (ESTWL)

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Abstract
The development of subject-specific word lists to assist EFL learners is becoming popular, as is the utilization of CLIL to teach English in academic areas of science. The purpose of this research was to investigate the effects of the instruction of English Science Textbooks Word Lists (ESTWL) and the CLIL approach on the Science Vocabulary Knowledge and Science Content Knowledge of Thai EFL students. A mixed-methods research design was employed to gather both quantitative and qualitative data using ESTWL-CLIL lesson plans, a Science Vocabulary Knowledge test, and a Science Content Knowledge test. All research instruments were validated by both content and language experts. The target groups were 3 levels of secondary school students studying at a large secondary school in Bangkok. The research findings were as follows: 1) the mean scores of the students in the three groups increased by a statistical significance of 0.05 for both vocabulary knowledge and science content knowledge after the implementation of the intervention, and 2) the qualitative results indicated that all students perceived the instruction of ESTWL and the CLIL approach to be positive. The study suggested a vocabulary pedagogy for science and language teachers for use in CLIL environments.

INTRODUCTION

English is a lingua franca widely used for worldwide communication. There have been many English language teaching methods developed over the years as English language instruction has changed and been combined with many different disciplines throughout its history. English-medium instruction (EMI) is an aspect of education that is becoming more popular around the world (Dearden, 2018; Macaro, 2018; Pun & Macaro, 2019; Pun & Thomas, 2020).

Students may find it difficult to learn subjects in a foreign language. Science, for example, requires students to understand a large variety of new concepts and language, and as a result, students' performance is partially dependent on their mastery of vocabulary. Therefore, teachers of foreign languages are always challenged to discover strategies to help students understand content being delivered in a language that they are currently learning (Tang, 2020). As teaching content in an additional language is becoming more common in schools throughout the world (Richards & Pun, 2021), as a form of immersion education, EMI shares some theoretical underpinnings with Content and Language Integrated Learning, hereafter CLIL (Dearden, 2018), utilized in European countries to offer increased opportunities for English language learning in content-subject areas. Thus, it is worth discussing the relation between EMI and CLIL. CLIL can be viewed as a form of EMI. While EMI broadly refers to the use of English as the primary language for teaching various subjects, CLIL represents a more specialized approach within EMI (Carrió-Pastor, 2021). In CLIL, the emphasis goes beyond language instruction alone; it integrates language learning with the learning of content from different disciplines. While both approaches involve using English as the medium of instruction, CLIL stands out for its specific focus on the integrated development of language and content skills.

There has been an advocacy for the adoption of EMI, particularly through the implementation of CLIL, in numerous pre-primary, primary, and secondary school systems across Asia. Given the novelty of this emphasis on the educational sector, there appears to be a shortage of empirical research on the practical implementation of EMI and CLIL in primary and secondary schools in Asia (Gilanyi et al., 2023).

According to Ball and Kelly (2016), CLIL is an instructional approach in which students are taught non-linguistic curricular content, such as geography or science, through the medium of a language that they are currently learning as an additional language. As the content and language become interconnected, this dual educational method focuses on both of these concepts together instead of individually (Coyle et al., 2010).

According to Phonlabutra (2007), the use of EMI in Thai primary, secondary, and higher education has expanded significantly. Students enrolled in EMI programs confront the challenge of studying academic subjects in their second language, which poses several difficulties for both students and lecturers. In Thailand, one of the forms that EMI has assumed is that of an English Program, or EP. Students enrolled in an EP take core curriculum subjects, such as science, in both English and Thai. Croyle and Chaturongakul (2015) observed that English as a second language learners of science struggle with science as a topic (Björklund et al., 2006), and scientific vocabulary (Phonlabutra, 2007; Oliver, 2017), highlighting problems with scientific terminology and subject comprehension which need to be addressed.

Several researchers have attempted to develop word lists that are specific to academic science subjects, such as in Marine Engineering (Durovic, 2021), Neurology (Li et al., 2022), and Computer Science (Uba et al., 2023), aimed at meeting the needs of learners. However, existing word lists are specifically designed for the instruction of English for Specific Purposes (ESP) for EFL university students and therefore their suitability for secondary or primary school EFL students has not been investigated. Thus, it is apparent that no textbook corpus-based word lists for secondary school students in the context of Thailand exist, in a country where EPs are continuously increasing in popularity and demand.

Evidence that utilizing CLIL improves learners' vocabulary exists (Huang, 2020; Lialikhova, 2018; Moghadam & Fatemipour, 2014), however, limited research has been conducted to investigate the link between CLIL implementation and technical science vocabulary knowledge and science content learning achievement. As a result, research to investigate the effects of English Science Textbooks Word Lists, hereafter ESTWL, in CLIL environments is essential. Furthermore, the usage of corpus-materials in EFL classrooms can enhance language learning (Kartal & Yangineksi, 2018), and scaffolding materials have excellent outcomes when used in science classes (Afitska, 2016). Based on the aforementioned literature and limited areas of research, this study aims to develop secondary school science word lists and integrate them into CLIL environments to improve students' science vocabulary and content knowledge in the context of Thailand.

LITERATURE REVIEW

1. Science vocabulary problems in an EMI context

Studies have shown that many students in English as a Medium of Instruction (EMI) encounter difficulties in comprehending textbooks, mainly because of an excess of unfamiliar words (Andrade, 2006) and technical vocabulary specific to the field (Chan, 2015; Kirkgöz, 2005). A lack of required vocabulary knowledge has been identified as a primary barrier faced by students in EMI situations (Başıbek et al., 2014; Chang, 2010). A lack of technical vocabulary knowledge is one of the most significant barriers to students understanding academic content in EMI programs, both in English as a Second Language (ESL) and English as Foreign Language (EFL) Hong Kong context (Evans & Green, 2007). Similar findings were discovered in Taiwanese EFL contexts by Chang (2010) in which students from technical disciplines struggled to comprehend key ideas in EMI courses, attributing poor academic performance to a lack of vocabulary knowledge. Because language use varies by subject, students' vocabulary requirements vary among EMI contexts.

2. Significance of vocabulary in science classrooms

Content vocabulary knowledge is directly connected to the problems many students encounter in dealing with the demands of content textbooks as a critical component of education at middle and secondary school levels (Armbruster & Nagy, 1992). Teachers would almost certainly agree that a significant component of students' trouble reading texts in their academic area of study is due to a lack of appropriate vocabulary knowledge. They would also agree that they teach vocabulary regularly and consistently yet see little benefit for their efforts. Because of the substantial use of scientific language to describe concepts, the vocabulary load in science textbooks creates a significant barrier to primary and secondary school students. Groves (1995), in a review of four secondary science textbooks, discovered that publishers continue to place a significant focus on science terminology. The frequent incorporation of technical terms in science textbooks elevates the complexity of language, making the readability level higher, but at the same time, it hinders comprehension during reading.

In science classrooms, the vocabulary of science differs from that of other academic fields. Students' comprehension of text, on the other hand, this is based on their vocabulary knowledge. Individuals with insufficient expertise or comprehension of scientific words have a dramatically diminished ability to comprehend content. This barrier to comprehension can cause an uneducated reader to feel as if they are on the outside looking in. Students are frequently perceived as outsiders because their schemas about the concepts and language that comprise content subjects are limited, limiting their capacity to read, comprehend, and communicate the subject itself. Students with restricted interpretations of language have limited understandings of the concepts and hence of the issue (Cooter & Flynt, 1996).

Furthermore, there is a common thread among the student concerns related to the four language skills mentioned earlier, particularly regarding how language proficiency influences academic success. Students in EMI topic courses have identified a lack of necessary vocabulary knowledge to learn through English as a major barrier (Başıbek et al., 2014; Chang, 2010; Evans & Green, 2007). Depending on their field of study, they have varied degrees of difficulty understanding technical vocabulary. Because language usage varies by region, students' vocabulary requirements range between EMI programs. One of the most significant instructional aims for any topic instructor, in theory, is to turn students who are typically outsiders in terms of language and idea competence into insiders.

3. Corpus-based language teaching in CLIL classrooms

A significant amount of research has been conducted to explore the usefulness of using corpus linguistics as a teaching method to stress how native English speakers use certain language forms, vocabulary items, and phrases. According to Maddalena (2001), utilizing authentic and real-life examples with L2 learners is more successful than using examples made up by an instructor that do not mimic real-life language use. Another benefit of using corpora for language training is that it allows students to actively work with and investigate language.

For many years, corpora have been used for instructional purposes in second and foreign language acquisition, but less so in CLIL environments. The primary goal here is not language acquisition per se, but rather topic knowledge in a foreign language that students already know at an advanced level. As a result, in each CLIL environment, corpora will be utilized differently. The capacity to view language in larger stretches and hence retrieve contextualized information of various kinds is the main advantage of corpora for CLIL. According to Morton's (2013) study, more than 90% of teachers preferred creating materials from scratch, while almost 90% changed genuine resources to make them more appropriate for their target learners. In comparison, only 20% of teachers utilized textbooks designed for native English-speaking students.

4. Corpus-based word lists in teaching vocabulary: Pedagogically oriented lists of vocabulary

According to Dang (2020), the use of corpus-based word lists in L2 curricula and training is a developing field in current vocabulary research. The most obvious advantage of these lists is in the creation of learning objectives. The construction of pedagogically directed lists of the most common and helpful vocabulary is one of the most advantageous ways in which corpora have helped with vocabulary studies. Among a number of studies on the development of science-specific word lists to meet the demands of students in their academic fields, the ESTWL was developed by the ESTWL was developed by the researchers of this study, based on lower secondary science textbooks used in EPs in Thai schools. It was created to assist lower secondary school students in their preparation for learning in science classrooms. There were 46 science textbooks used in the English Science Textbook Corpus (ESTC). There are 2,076,389 words in the corpus, and 408-word types met the criteria of the expert-judged approach by science teachers. Fifteen subject matter experts giving a final rating from a scale adapted from Chung and Nation's (2004) study agreed that 480 word-types are technically appropriate and suitable to create the ESTWL, divided into 3 sub-lists: Physical Science Word Lists, Biological Science Word Lists, and Earth & Space Science Word Lists. The ESTWL series is available at *https://sites.google.com/view/estwl.*

The ESTWL can be used to set vocabulary learning objectives, assess vocabulary comprehension and progress, assess text complexity and richness, adapt reading materials, create vocabulary learning resources, define academic curriculum vocabulary requirements, and more (Gardner & Davies, 2014). Since the lists are divided into 3 sub-lists and 9 sub-topics, users can choose the lists more conveniently and accurately from the science topics being used and learned in that semester. With a ready-made list of the most frequently used vocabulary extracted from English science textbooks, course material designers and CLIL teachers can choose whether to use them as extra material, compile new textbooks and exercises with excerpts and examples taken from authentic textbooks, or use the list in any other way they deem appropriate.

CLIL is an educational approach in which students learn non-linguistic topics and subjects using a second/foreign/additional language (L2) (Coyle et al., 2010), and it has emerged as a prominent research domain in bilingual/foreign language education. Previous research on CLIL has primarily concentrated on its multiple definitions, language and content learning results (Cenoz et al., 2014; Dalton-Puffer et al., 2014), and pedagogical concerns (Llinares et al., 2012). Students in CLIL science classrooms are expected to master several things at the same time, including abstract scientific knowledge and concepts, cognitive organizing and argumentative skills, conversational language used in classroom interaction, and academic language used to understand and express their science knowledge. It is not surprising that students struggle with CLIL, and one cannot assume that students can pick up all of these learning targets.

5. CLIL implementation in science classrooms

CLIL has been proved to be effective for teaching in EFL science classrooms and it is evident that there are a variety of aspects in English. Beaudin (2021) conducted a study assessing the impact of CLIL program on Taiwanese primary school students. The results indicated that students exhibited significant improvement in both science and language content learning, as evidenced by higher scores on posttests and sustained success on delayed posttests. Student feedback revealed positive attitudes toward CLIL, with enjoyment of participation, perceived enhancement of English skills through CLIL content learning, and motivation to engage in future

CLIL courses. The results corresponded with those of Moghadam and Fatemipour (2014) when they investigated the link between acquiring and growing vocabulary and learning English in CLIL programs for Iranian secondary school students. Because of the CLIL technique and textbooks used for teaching scientific and mathematical topics, students are able to build and remember vocabulary better than regular school programs. In addition to increases in vocabulary, science content has been effectively delivered to students studying in CLIL environments. Additionally, Huang (2020) explored the impact of CLIL in science education in a primary school setting in Taiwan, specifically examined students' views on CLIL concerning both their subject matter comprehension and language proficiency. The findings showed that CLIL helped expand students' vocabulary size, develop students' understanding of science, and inspire positive expectations in students regarding learning additional topics in English.

In Thailand, some studies confirmed the effectiveness of CLIL in developing English skills for Thai EFL learners. Chaiyaratana and Ekkayokkaya (2022) integrated CLIL into dialogic teaching in science classrooms to enhance the English oral communication ability of Thai primary school students. The findings revealed that students' English oral communication ability improved with statistical significance. Likewise, Suttipun and Sappapan (2019) also developed lower secondary school students' reading comprehension skills through utilizing the CLIL approach in English classrooms. The findings confirm that students' reading skills in English are improved, as well their engagement in classroom activities. However, these studies also highlight that little attention has been given to science vocabulary knowledge in CLIL science classrooms, especially at secondary school level. At this level, students are expected to read texts containing different kinds of vocabulary and academic vocabulary, which is very different from the words they use for general communication. For many students, when word recognition declines, comprehension of texts will also decrease. Middle school teachers see this difficulty in their classrooms and are often uncertain about how to assist their students with academic vocabulary development (Greene & Coxhead, 2015). Taboada (2012) also emphasized that knowledge of science vocabulary was a better predictor of reading comprehension in science than general vocabulary knowledge; however, Kim (2016) noted that research on specialized, technical vocabulary of science remains limited.

CLIL is one of the most effective instructional methodologies for improving students' reading, writing, and vocabulary skills, and attracts student's interest in both international and Thai contexts, However, there is still room for improvement in the design of CLIL science instruction at the secondary school level, particularly because there has been no research using textbook word lists to improve students' vocabulary knowledge, nor has there been any attention given to science content learning achievement in CLIL classrooms in the context of Thailand. Therefore, this study's conceptual structure is as follows.

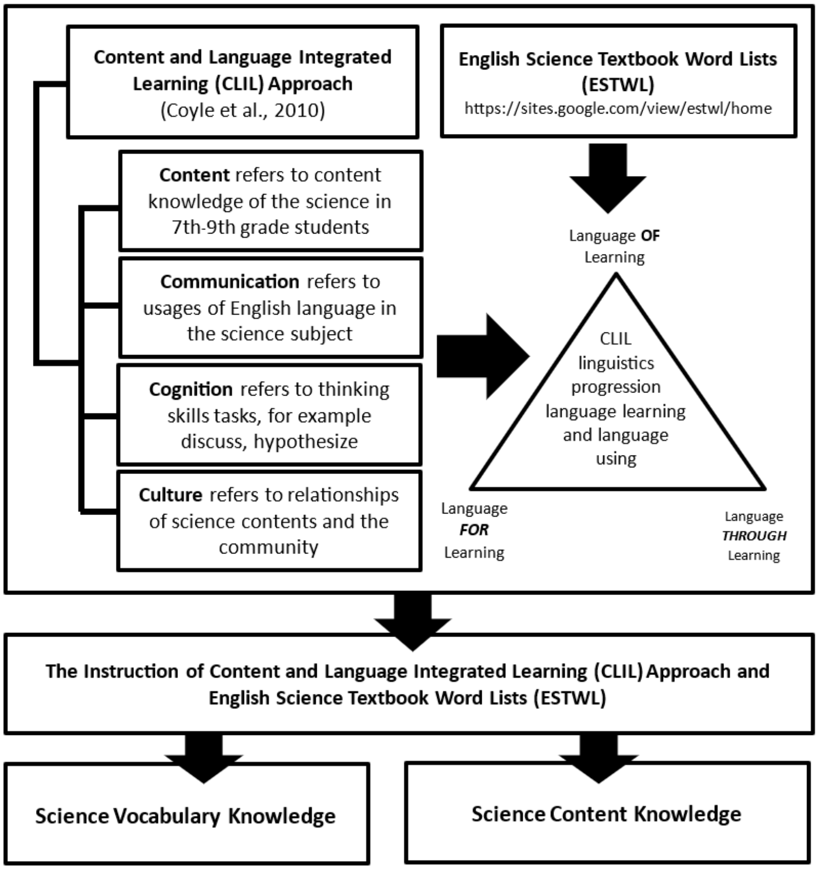

Figure 1 The conceptual framework of the research

The framework shows principle of CLIL and identify the place that ESTWL can be integrated into the 4C framework, specifically, communication. The Language Triptych serves as a tool for analyzing language requirements in various Content and Language Integrated Learning (CLIL) contexts, making a clear distinction between different types of linguistic demands that impact CLIL. It also offers a framework for conceiving language usage as a means for knowledge construction (Dalton-Puffer, 2008). Importantly, the Triptych does not supplant grammatical progression; instead, it complements it. It aids learners in language usage by examining CLIL's vehicular language from three interconnected perspectives: the language of learning, language for learning, and language through learning. In this study, the ESTWL was connected to language triptych part "Language of Learning".

Considering the significance and the research gap, this research aims to address the following research questions:

1. To what extent can the instruction of ESTWL and the CLIL approach enhance the science vocabulary knowledge of Thai lower secondary school students?

2. To what extent can the instruction of ESTWL and the CLIL approach enhance the science content knowledge of Thai lower secondary school students?

3. What are the perceptions of Thai lower secondary school students toward the instruction of ESTWL and the CLIL approach?

METHODOLOGY

1. Research design

This study employed an embedded experimental mixed-methods design and a one-group pre-test post-test design. Creswell (2014) states that the embedded mixed methods design allows researchers to collect one or more forms of quantitative and qualitative data within a larger research design, such as an experimental study. This provides different types of data to address research questions, and that data can be collected before, during, and/or after the experiment. In an embedded experimental mixed methods design, quantitative data predominates, while qualitative data is included to answer secondary research questions (Creswell & Clark, 2017).

This study aimed to investigate the effects of the instruction of the CLIL approach and ESTWL on the science vocabulary knowledge and science content knowledge of Thai lower secondary school students. Three groups of lower secondary school students (Grades 7, 8, and 9) attended a twelve-week English-CLIL course in the first semester of 2023. The research participants took a pretest, received the treatment (CLIL-ESTWL Instruction), took a posttest, completed a questionnaire, and had semi-structured interviews. Quantitative data obtained from comparing pretest and posttest scores provided answers to Research Questions 1 and 2, while qualitative data obtained from five semi-structured interviews provided answers to Research Question 3. To confirm whether the intervention could be used when changing sub-wordlists to align with differing science content at different levels, three groups of students in 3 levels of lower secondary school were recruited as the participants of the study. The research design is shown in Figure 2.

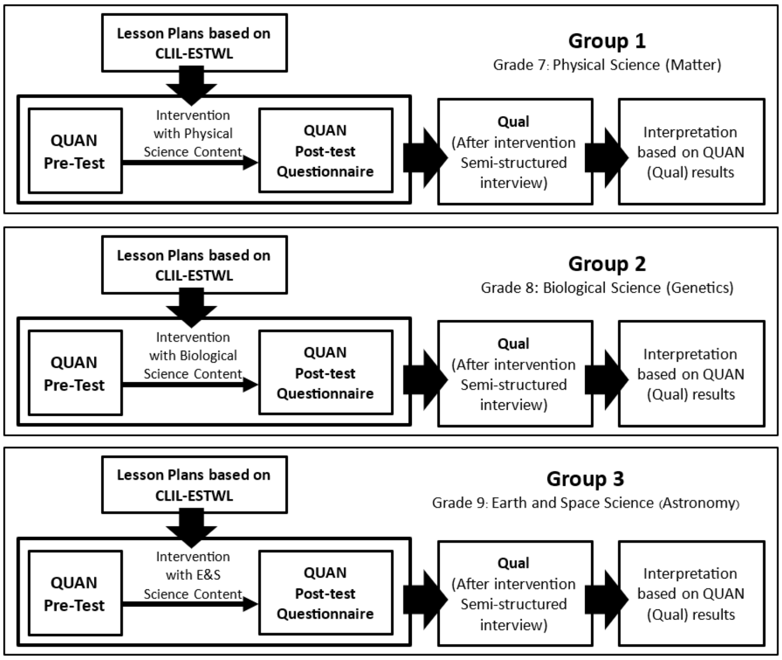

Figure 2 The research design

2. Participants and context

The participants were lower secondary school students in EPs. They were selected using the convenience sampling method. The participants were all Thai EFL students with mixed-ability proficiency. Forty-five students studying in Grades 7–9 in three EP classrooms at a large-sized public school in Bangkok, Thailand, voluntarily participated in the study. Each class consisted of 15 students, and therefore, a total of 45 participants. All participants were informed about the study, their rights to participate in and withdraw from the study, and data protection and confidentiality. A consent form was then collected from each student before carrying out the study.

3. Research instruments

The research instruments consisted of science vocabulary knowledge and science content knowledge tests (pre-tests and post-tests), the perceptions questionnaire and semi-structured interviews and the lesson plans. The purpose of the pre-tests and post-tests was to evaluate the level of vocabulary and content knowledge both before and after the intervention. Developed by the researcher, the science vocabulary knowledge tests employed in this section were segmented into three components, matching, sentence writing, and cloze test. In terms of science content knowledge, the tests were also categorized into three sections, namely multiple Choice, completing conceptual mapping, and short answer. The duration allocated for both the pretest and posttest sessions was 90 minutes. Both tests were validated as follows: (1) content validity, checked before the pilot test was conducted by science and English language teachers, was found to have an index of item objective congruence ranging from 0.67 to 1.00, (2) difficulty index ranked from 0.33 to 0.77, and (3) reliability (Cronbach's alpha) was found to be 0.85.

The questionnaire was designed to elicit the lower secondary school students' perceptions after the implementation of the instruction of ESTWL and CLIL approach. It consisted of seventeen Likert-type items using a five-point rating scale and three open-ended questions, both Thai and English. The questionnaire focused on the students' views, beliefs, and perceptions regarding the improvement in their science vocabulary and science content through the instruction of ESTWL and CLIL approach in the classroom. Semi-structured focus group interviews were used to collect data after the instruction. Nine participants were selected to participate in the interviews. They were selected based on their level of vocabulary and content knowledge proficiency, which was determined by the mean scores of the tests. Three participants from each group with low, moderate, and high levels of vocabulary and content knowledge were interviewed. The interviews were conducted in Thai to prevent any language-related misunderstandings. A sample interview question was: "Did learning English on the CLIL-ESTWL course give you the support you needed to learn better in the science classroom? How?".

4. Data collection and analysis

The implementation of the instructional component and data collection was conducted by the researcher. The CLIL-ESTWL lesson plans were developed according to the 4C's framework of

CLIL (Coyle et al., 2010), namely content, communication, cognition, and culture, and the English Science Textbook Word Lists (ESTWL) developed by the researchers are available at *https://sites.google.com/view/estwl/home*. Prior to the intervention, 8-unit plans were developed for each group of students. Each unit took one week to complete and consisted of three periods of 150 minutes in total. The lesson plans underwent validation by three experts specializing in science teaching in English Program classrooms and English language teaching. This validation process aimed to ensure the quality and effectiveness of the instructional materials. The experts brought expertise in both content and pedagogy, ensuring alignment with curriculum objectives and the enhancement of students' scientific understanding and language proficiency. This rigorous validation not only added credibility to the lesson plans but also contributed to their overall quality and suitability for achieving the educational goals of the Program. Following the validation, the lesson plans underwent practical application in a pilot study involving students of a comparable demographic. Adjustments were made to accommodate the school's class schedules, and additional input from students was incorporated regarding the tasks in each activity. Subsequently, after the refinement based on these considerations, the intervention was implemented over a period of ten weeks.

Once the instruments were validated, piloted, and revised, they were administered as follows. First, the pre-test was administered to students before the 10-week lesson plans were employed in the classroom to implement the CLIL-ESTWL with the students. Then, the post-test and questionnaire were administered to students. Subsequently, semi-structured interviews were carried out to gather the perception of the participants regarding the teaching of ESTWL and the CLIL approach. The participants in the interviews were intentionally grouped into three categories according to their grades, with each group consisting of five individuals. The categorization was based on their average scores in both pre-tests and post-tests. The interviews were conducted subsequent to the post-test. Prior consent to record the interviews was obtained from the participants, and the researcher also documented the discussions through written notes. Following the student interviews, the researcher opted to gather additional information and evidence regarding the advantages gained by students who took part in the CLIL-ESTWL class. Consequently, semi-structured focus group interviews were conducted with foreign science teachers in mainstream classrooms.

In terms of data analysis, to answer the first and second research questions on the effectiveness of the instruction of CLIL and ESTWL on science vocabulary and content knowledge, the data obtained from pre-tests and post-tests were quantitatively calculated. Descriptive statistics (mean and standard deviation) and a Wilcoxon signed-rank test was used to analyze the results of the tests to determine whether a statistical significance between pre- and post-tests existed with a level of significance of 95 percent. The reason why a Wilcoxon signed-rank test was adopted in this study is due to the non-normally distributed data (non-parametric).

To answer the third research question, the students' perception questionnaire was conducted to elicit all the participants' perceptions of the use of the instruction of ESTWL and CLIL approach regarding the improvement of science vocabulary knowledge and science content knowledge. The means and standard deviations were calculated, and the scores. Then the scores were categorized into the five levels as shown below, and the results are as in table 1.

The semi-structured interviews were also qualitatively analyzed using content analysis to report perceptions towards the instruction of CLIL and ESTWL to address research question 3 as well.

Table 1
The Criteria of the participants' perceptions of the use of the instruction of ESTWL and CLIL approach

Mean (x̄)	Description of Perception
4.21 -5.00	very high
3.41 -4.20	high
2.61 -3.40	moderate
1.81 -2.60	low
1.00 -1.80	very low

RESULTS

The findings of this study, which respond to the three research questions, are divided into three parts: 1) Effects of the instruction of CLIL and ESTWL on science vocabulary knowledge, 2) Effects of the instruction of CLIL and ESTWL on science content knowledge, and 3) students' perceptions toward the instruction of CLIL and ESTWL.

1. Effects of the instruction of CLIL and ESTWL on science vocabulary knowledge

In response to the Research Question "To what extent can the instruction of ESTWL and the CLIL approach enhance the science vocabulary knowledge of Thai lower secondary school students?", a Wilcoxon signed-rank test was conducted. The total pretest and posttest scores of the students were calculated for mean scores ($\overline{X}$) and standard deviations (SD). Next, the scores of the pretest and posttest were compared and analyzed using a Wilcoxon signed-rank test in order to examine whether there was a statistically significant difference. The analysis of the results revealed that the posttest scores increased significantly after the integration of ESTWL into CLIL for ten weeks, implying that the students had made a substantial improvement in their science vocabulary knowledge due to participating in the study.

Table 2
Comparison of the students' science vocabulary knowledge scores, before and after receiving the implementation of the integration of ESTWL into CLIL

		Statistics						
	n	Pretest		Posttest		Mean difference	Wilcoxon W	Sig- (2 tailed)
		$\underline{X}$	*SD*	$\underline{X}$	*SD*			
Grade 7th	15	7.07	1.58	9.73	1.10	-3.5	0.00	0.001
Grade 8th	15	6.13	0.92	9.33	0.62	-3.0	0.00	<.001
Grade 9th	15	6.93	1.03	9.47	0.64	-2.5	0.00	<.001

*p <. 05

As indicated in Table 2, the pretest and posttest scores for the students' science vocabulary knowledge were significantly different at the level of .01; the students' posttest scores were statistically significantly higher than the students' pretest scores at p < .001. in all three groups of students. In addition, biserial correlation's effect size value (= 1) revealed a large practical significance. These results indicate that there was an increase in the students' science vocabulary knowledge posttest scores after receiving the instruction of CLIL and ESTWL for ten weeks, implying that it was effective in improving the students' overall science vocabulary knowledge regardless of different science topics.

2. Effects of the instruction of CLIL and ESTWL on science content knowledge

In response to Research Question 2 "To what extent can the instruction of ESTWL and the CLIL approach enhance the science content knowledge of Thai lower secondary school students?", a Wilcoxon signed-rank test was conducted to measure the students' science content knowledge pretest and posttest scores. The analysis of the results revealed a significant shift in the students' science content knowledge scores, implying that the students made a substantial improvement in their science content knowledge after participating in the study.

Table 3
Comparison of the students' science content knowledge scores before and after receiving the implementation of the integration of ESTWL into CLIL

	n	Statistics						
		Pretest		Posttest		Mean	Wilcoxon	Sig-
		$\underline{X}$	*SD*	$\underline{X}$	*SD*	difference	W	(2 tailed)
Grade 7^{th}	15	6.33	1.59	9.47	0.74	-3.5	0.00	0.001
Grade 8^{th}	15	6.53	1.06	9.60	0.91	-3.0	0.00	<.001
Grade 9^{th}	15	6.20	0.77	8.80	0.68	-2.5	0.00	<.001

*p < .05

As presented in table 3, the pretest and the posttest science content knowledge scores for the students were significantly different at the level of .01; the students' posttest scores were statistically significantly higher than the students' pretest scores at p < .001. in all three groups of students. In addition, biserial correlation's effect size value (= 1) revealed a large practical significance. These results highlight an increase in the students' science content knowledge posttest scores after receiving the instruction of CLIL and ESTWL for ten weeks, implying that it was effective in improving the students' overall science content knowledge in all three levels.

3. Students' perceptions toward the instruction of CLIL and ESTWL

In this section, the Research Question 3 was "What are the perceptions of Thai lower secondary school students toward the instruction of ESTWL and the CLIL approach?".

3.1 Results from the Perception Questionnaire

Table 4
The findings obtained from the students' Perception Questionnaire (Means, Standard Deviations, and Levels of Range Results from the Perception Questionnaire)

Item	Statements	Mean (n = 45)	*SD*	Level
1	Learning English on a CLIL-ESTWL course makes me feel happy to learn science vocabulary.	3.93	0.69	high
2	Learning English on a CLIL-ESTWL course makes me feel happy to learn science content in English.	4.05	0.67	high
3	Learning English on a CLIL-ESTWL course helps me to improve my science vocabulary knowledge.	4.45	0.67	high
4	Learning English on a CLIL-ESTWL course helps me to improve my science content knowledge.	4.30	0.71	high
5	Learning English on a CLIL-ESTWL course encourages me to participate in classroom learning activities.	4.10	0.73	high
6	Learning English on a CLIL-ESTWL course helps to promote good relationships with my friends.	3.85	0.79	high
7	Learning English on a CLIL-ESTWL course helps promote good relationships with my teacher.	3.93	0.75	high
8	Learning English on a CLIL-ESTWL course encourages me to be more interested in learning science vocabulary.	4.18	0.67	high
9	Learning English on a CLIL-ESTWL course encourages me to be more active in learning science content in English.	4.23	0.76	high
10	Learning English on a CLIL-ESTWL course raises my awareness of learning science vocabulary.	4.03	0.72	high
11	Learning English on a CLIL-ESTWL course raises my awareness of learning science content in English.	4.10	0.77	high
12	Learning English on a CLIL-ESTWL course encourages me to be more confident in using English to communicate.	3.98	0.82	high
13	Learning English on a CLIL-ESTWL course supports me to cooperate and work with others.	4.25	0.70	high
14	I can apply the techniques and experiences of what I have learned on the CLIL-ESTWL course to other subjects.	3.90	0.80	high
15	Learning English on a CLIL-ESTWL course supports me when learning more about the meaning of new vocabulary.	4.48	0.71	high
16	Learning English on a CLIL-ESTWL course helps me to memorize and recognize new vocabulary more easily.	4.20	0.81	high
17	Learning English on a CLIL-ESTWL course helps me to use vocabulary in various contexts correctly.	4.08	0.75	high
	Overall	4.12	0.74	high

Table 3 reveals the means, standard deviations, and levels of perception of the overall items, the four overall parts, and each individual item obtained from the analysis. The overall mean scores of the participants' attitudes towards the CLIL-ESTWL instruction were reported at a high level (M = 4.26, SD = 0.68), and for the individual items, all 17 items were reported at a high level. The highest mean score was found in Item 15: Learning English on a CLIL-ESTWL course supports me when learning more about the meaning of new vocabulary (M = 4.48, SD = 0.71). The lowest mean score corresponded with item 14: I can apply the techniques and experiences of what I have learned on the CLIL-ESTWL course to other subjects (M = 3.90, SD = 0.8).

3.2 Results from the semi-structured interview

The findings obtained from the semi-structured interviews revealed that in general, the participants had positive perceptions towards the instruction of CLIL and ESTWL. They all agreed that the instruction helped them to memorize and recognize science vocabulary better and increase their science content knowledge. Moreover, they also mentioned that it assisted them in learning new vocabulary. Examples of responses for the general perception towards the instruction of CLIL and ESTWL are as follows:

> *"It helped me understand science vocabulary more than in the past. Some words that I did not know before, I now know. It is like difficult science words have become easy now – I can read and understand them better."* [Student 1]

> *"Learning this way helped me to understand science content because the teacher allowed me to think and share ideas with peers and the teacher. We sought answers together as if we were learning together."* [Student 9]

Regarding perception towards the instruction of CLIL and ESTWL, the responses revealed that the participants were able to comprehend science content better. The different activities from the CLIL approach are helpful in preparing students for mainstream science classes. Specifically, students reported that the instruction enhanced their comprehension of science content as they were actively involved in the learning process. Getting additional classes that allowed time to ask questions was reported to help some of them to comprehend the science content better. Responses regarding perceptions towards the instruction of CLIL and ESTWL are as follows:

> *"The activities we did in classes introduced me to science vocabulary and allowed me to use them many times."* [Student 7]

> *"We have more chance to use science vocabulary and get to know the meanings before learning them in the mainstream classroom. This can help me when meeting them again and to use them appropriately."* [Student 3]

> *"I always ask the teacher in this class about some difficult content from mainstream classes. This is good for reviewing after the science class and we can know how to pronounce vocabulary correctly too."* [Student 5]

To summarize students' perceptions of CLIL and ESTWL instruction, the data from both the questionnaire and the interviews demonstrate that the learners had favorable perceptions towards the instruction. They scored all questionnaire items positively at a high level, and according to the interview data, students viewed the instruction of CLIL and ESTWL as a helpful intervention that helped them recognize and utilize science vocabulary. They stated that practicing with CLIL exercises helped them comprehend the science content better.

In addition, concerning teachers' interviews, it was discovered that three science teachers also expressed that their students had improved in learning science content, and that when doing activities in class, it was much faster and more convenient to teach them because the teachers did not have to worry about difficult vocabulary or concepts that they may have had to explain. Some responses regarding the feedback from science teachers are as follows:

> *"The students in my class get better in terms of science vocabulary and I don't have to worry about taking some time to explain to them since we have a load of content to cover. The extra classes assist me and save my time so much."* [Teacher 1]

> *"I wish we could have classes like this throughout the whole program. Sometimes I have to teach language and it takes a lot of time from teaching science concepts. I also love the vocabulary list that you provide us."* [Teacher 2]

DISCUSSION

The present study examined the effects of the instruction of CLIL and ESTWL on Thai lower secondary school students' science vocabulary and content knowledge across three levels. The findings showed that learners across the three levels had significantly improved their science vocabulary and content knowledge after the instruction of CLIL and ESTWL. This implies that CLIL and ESTWL work effectively in developing and improving students in terms of both science vocabulary and content knowledge.

In terms of science vocabulary and science content knowledge, vocabulary acquisition is of great importance to science literacy because it is a major factor in understanding and applying science in context during classroom instruction and assessment. (Andazola, 2019). The students receiving the instruction of CLIL and ESTWL gained science vocabulary knowledge, which aligned with the results from a study by Huang (2020) whereby findings suggested that CLIL can help expand students' vocabulary size and understanding of science. Knowing more science content can indeed support the development and retention of science vocabulary. A deeper understanding of scientific concepts and context often leads to more effective acquisition and utilization of related terminology. Given that CLIL science subjects emphasize the development of science content and English (Coyle et al., 2010) and ESTWL emphasize vocabulary and new terminology for co-constructions in CLIL, the instruction implemented led to frequent usages of content specific vocabulary as a means to co-construct new science knowledge through CLIL activities in the classrooms.

The findings were consistent with those revealed in the study of Chow et al. (2023) which indicated that students' expressive English vocabulary knowledge was improved due to ample opportunities provided for students to use new words in interactions with peers and the teacher. Nikula (2015) mentioned that CLIL can lead to improved academic performance in science subjects. Students often perform as well as, if not better than, their peers in traditional educational settings. This is also consistent with the study by Morton (2015) that contextual learning leads to better vocabulary acquisition in science classrooms. Science vocabulary is often interconnected with various scientific principles and theories, and learning science content helps individuals see the relationships between terms and concepts, making vocabulary more coherent. Knowing more science content can indeed support the development and retention of science vocabulary. A deeper understanding of scientific concepts and context often leads to more effective acquisition and utilization of related terminology.

In terms of students' perceptions towards CLIL and ESTWL instruction, results from both the questionnaires and the interviews show that the students had positive perceptions towards the instruction. These results are in line with those found by Mahan and Norheim (2021) which indicated that CLIL students often have more positive perceptions toward learning, and this can have a significant impact on their overall learning experience, including science education. CLIL teaches science vocabulary in the context of scientific content, making it more meaningful and easier to understand. Research conducted by Sanad and Ahmed (2017) supported the idea that active engagement in CLIL lessons enhances vocabulary retention and use. In CLIL classes, students actively engage with scientific content, and use science vocabulary to communicate in EMI classrooms.

Pedagogical implication

The study contributes theoretically by introducing Corpus-Based Word Lists and CLIL as innovative approaches for science classes, providing practical integration in English learning in Thailand. The ESTWL can serve as a guideline for teachers, course designers, and material developers in preparing teaching materials especially in Asian contexts. Pedagogically, the findings offer fundamental guidelines for designing CLIL instruction in Thailand and other English as a Foreign Language (EFL) contexts, potentially extending to various disciplines. The research importance lies in suggesting classroom methods using CLIL and corpus-based approaches to enhance science vocabulary knowledge among Thai lower secondary students, acting as a pioneer in integrating corpus linguistics, English medium instruction, and English language teaching. The study encourages further research on CLIL instruction and corpus-based resources for various language skills, contributing to a comprehensive understanding of implementing CLIL with a corpus-based approach in Thai secondary schools.

CONCLUSION

This study reveals the effectiveness of the instruction of CLIL and ESTWL for developing and improving science vocabulary and content knowledge of Thai students studying in an EP at lower secondary education levels. This study proves that to some extent, not only does the CLIL approach combined with word lists improve the achievement of Thai EFL students, but this instructional method is also favorable to them. In terms of research importance, the findings also suggest methods in which the study may be conducted in classrooms using both a CLIL approach and a corpus-based approach to enhance science and English achievement. As a result, the information obtained in this study may aid in developing a solid foundation for the implementation of CLIL, utilizing corpus-based word lists to promote science vocabulary and science content knowledge among secondary school students in Thai schools. The researcher found that involving the students in appropriate CLIL and ESTWL activities led to positive changes in the students' English and science achievements, and it was useful for the students and for their future learning in EMI-environments.

LIMITATIONS AND RECOMMENDATION FOR FURTHER STUDIES

This study also had some limitations which should be acknowledged. Firstly, the study was conducted with only one group and a small number of participants over a relatively short period of time. Thus, future studies could be conducted with two groups, and with a larger number of participants to compare the impacts of explicit instruction of CLIL and ESTWL on the experimental groups. Moreover, students' performance should be assessed for pronunciation or literacy, or oracy skills development. This may lead to an enhancement of vocabulary and other areas of language learning including reading, writing, listening, and speaking. Therefore, future research could go beyond vocabulary to investigate other areas of language learning holistically. In terms of science content knowledge, since the CLIL approach was also aimed at enhancing thinking abilities and cultural awareness, further studies could also investigate science thinking ability, such as scientific reasoning and scientific argumentation, as well as scientific culture in scientific communities. When students have enough input, especially regarding science vocabulary, studying how they apply that subject-specific vocabulary knowledge to other skills as mentioned could contribute to science education in EMI contexts. This may promote positive learning attitudes, motivation, or self-efficacy in other subject EMI programs. Finally, future studies could investigate the extent to which the intervention in this study is transferrable to other courses or content subjects, including social studies, mathematics, and physical education.

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