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Expanding Students' Linguistic Repertoire through CLIL Teaching and Learning – an Action Research in a High School Chemistry Classroom in Taiwan

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Abstract

With the implementation of the new curriculum reform in 2018, the Ministry of Education in Taiwan suggested that students should use English not only for interpersonal communication but also to communicate with other content subject areas. However, educators and researchers need to focus more for learners using English as a foreign language (EFL learners) in learning content subjects, e.g. science. Therefore, strong language support, such as that under Content and Language Integrated Learning (CLIL) approaches, is essential for Taiwanese students who are still mostly EFL learners. This approach can enhance their understanding of chemical knowledge using English as a medium of instruction (EMI). The central thesis of this study is students' performance in a rich language support classroom context in high cognitive demand in a chemistry classroom. This study aims to monitor students' learning progress to evaluate the potential effectiveness of CLIL in 2 months of learning and teaching in chemical kinetics and dynamic equilibrium. Research questions include the extent of students' knowledge acquisition in vocabulary and sentence level and teachers' and students' perceptions of CLIL instructions.

This action research, conducted with a group of 29 students, began with content and language instruction through CLIL bridging pedagogies (Lin, 2016) in Grade 10 chemistry lessons. The students' delayed post-test was then analysed quantitatively using a t-test to measure their learning outcomes. Furthermore, oral and written discourse was analysed qualitatively to determine teachers' effectiveness towards teaching and learning using CLIL in the cognitive domain. This comprehensive approach ensures a thorough understanding of the impact of CLIL on both students and teachers. Additionally, semi-structured questionnaires were utilised to understand students' attitudes after CLIL instruction. The pedagogical and empirical implications of this study will be discussed in detail, providing Taiwanese educators with a comprehensive understanding of the benefits of CLIL in content lessons.

Keywords: Content and Language Integrated Learning (CLIL), English as a Medium of Instruction (EMI), English as a Foreign Language (EFL), Action Research, Taiwan.

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Introduction

Taiwan will become a bilingual country in 2030 after implementing a national bilingual education policy in 2018. Taiwanese adults at that time should be competent in using English in various contexts. In response, the Ministry of Education in Taiwan suggested that students use English for interpersonal communication and to communicate with various cognitive domains to be competent in using English in daily scenarios and academic contexts. Some tertiary institutions and high schools implemented various bilingual education programmes with diversified results in response to the government's proposal. Lin (2021) reported that some technology students in higher education reckoned that such promotion of English learning was simply a market-driven and policy-driven act, while some students in linguistics major had already been accustomed to using English for academic purposes. That means there are diversified opinions on English teaching and learning among various disciplines, depending on the extent of English usage in lessons. When students are accustomed to using Chinese as the only medium of instruction before Grade 12, such an abrupt change in the medium may negatively affect students. Thus, promoting bilingual education should start when students are young. Cadias (2020) reported a blueprint for a bilingual education programme in a high school in Taiwan. The blueprint included a 3-year preparation of a bilingual education programme with various language-bridging pedagogies such as CLIL, translanguaging and code-switching. However, the effectiveness of teaching and learning has not yet been reported. However, researchers have focused little on this issue for learners using English as a foreign language (EFL learners) in learning content subjects. Also, in the existing curriculum, Taiwanese students only learn English in English lessons. They are not exposed to an English environment when they are off from English lessons. However, Taiwanese teachers also focused little on this as it is relevant to students' university entrance examination assessments. If this situation continues, achieving the government's expectation that Taiwanese students can communicate effectively in the cognitive domain will not be easy. Therefore, planning lessons that help students communicate in some subjects using English is urgent. When they are known to use English for their subject matter, Taiwan high school students can start using English for work and study in the future. Therefore, strong language support, such as that under Content and Language Integrated Learning (CLIL) approaches, is essential for Taiwan high school students who are still mostly EFL learners.

However, science educators generally focus on something other than bilingual education. Science teachers in Taiwan teach science in Chinese, not English, causing a weak relationship between science and English in Taiwan's education curriculum. Therefore, science educators in Taiwan need to focus more on this issue for EFL learners. Consequently, Taiwanese students do not have adequate exposure to science learning in English. There have been studies (e.g. Coxhead & Boutorwick, 2018) on vocabulary acquisition in the EFL context. However, in the context of high school education, more is needed to help students build up a science vocabulary list. What they need to acquire and learn needs to be explained at a word level. Therefore, strong language support, such as that under CLIL approaches, is essential for Taiwanese EFL students while receiving sophisticated chemical knowledge using English as a medium of instruction (EMI). As a result, students can read and extract essential information from the text in chemistry materials and produce their work using subject-specific vocabulary at a sentence level. There are numerous studies on EMI education in Taiwan regarding English teaching and learning, particularly in a high school context (Huang, 2020; Tsui, 2017). However, there are no studies on CLIL Chemistry education in Taiwan in the high school context. This study can serve as a pilot and shed light on CLIL approaches in the Taiwan context to give more insights to scholars and teachers in Taiwan for building a solid and fundamental block in fostering Taiwan to be a bilingual country.

Research gap to be filled

There are few studies concerning language learning among EFL students in chemistry. Many theories have been established solely for content teaching in chemistry. However, there are fewer studies concerning language learning related to chemistry. In language learning, much work has been done for science but has yet to explicitly targeted at chemistry, and those that do exist have focused on ENL or ESL students (Johnstone & Selepeng, 2001). Many studies have been done on language acquisition (Coxhead & Boutorwick, 2018) for EFL students but not for content knowledge acquisition in chemistry (Tsang, 2020). Worse still, there are no studies covering language acquisition in science subjects in the Taiwan context.

Consequently, the current study evaluates students' learning effectiveness in acquiring chemistry knowledge in a classroom using English as a teaching medium in a Taiwan classroom.

The research questions in this study are not just academic inquiries, but they hold the potential to reshape our understanding of language learning in the context of chemistry education. They include:

1. What is the extent of effectiveness of students' learning the vocabulary and learning how to write explanations using CLIL pedagogies and
2. What are teacher's and students' attitudes towards CLIL instruction?

Literature Review

Taiwan as a bilingual country

Taiwanese government was planning to become a bilingual country by 2030 to cope with globalisation and internationalisation and boost people's English proficiency to enhance international competitiveness (National Development Council, 2018). When implementing bilingualisation in Taiwan comprehensively, the Council suggested that content and language integrated learning (CLIL) should be promoted in primary and secondary schools. That means English teaching and learning is not only the responsibility of English teachers. Content subject teachers also need to shoulder the responsibility of promoting English usage in content subjects to nurture students as international citizens who are adaptive to globalisation changes. As chemistry teachers, a teacher in Taiwan teamed up with another teacher-researcher in Hong Kong to borrow successful EMI and CLIL experiences from a Taiwan high school classroom, as revealed in this pilot study.

BICS and CALP

Cummins (2011) defined two English types: Basic Interpretational Communication Skills and Cognitive Academic Language Proficiency (CALP). BICS is used for social and conversational situations, while CALP is used for academic purposes. In Taiwan's educational context, having English lessons seems the only way for Taiwan students to learn

English. It is easier for teachers to teach BICS and CALP with limited teaching time. At the same time, students in Taiwan cannot acquire sufficient CALP for future work or study. When Taiwan's English proficiency stagnates, their English standard is insufficient to use English effectively whenever needed. Taiwan's competitiveness will be significantly reduced compared with the world's world counterparts.

While finding ways to expand Taiwanese students' linguistic repertoires, especially CALP, the existing curriculum posed a large obstacle– students learn content subjects in Chinese, not English. Using English in content subjects is not that relevant in learning content subjects when it comes to assessment. However, the LAC adjunct lessons were designed for some Taiwan students (n = 29) in a class as a pilot study to increase students' CALP in chemistry, one cognitively demanding subject in senior high schools, after formal lessons. With its promising results, this pilot study serves as a start for Taiwanese educators to equip themselves to be bilingual teachers. With their newly acquired skills, they can design practical teaching and learning activities that will significantly increase future students' CALP of content subjects, inspiring a positive change in Taiwan's educational system.

Content and Language Integrated Learning (CLIL)

Content and Language Integrated Learning was defined as' a dual-focused educational approach in which an additional language is used to learn and teach of both content and language' (Coyle et al., 2010). However, having content and language as the only foci is not that applicable to the authentic classroom settings. Therefore, various CLIL frameworks were developed, including the 4Cs framework. The 4Cs framework of CLIL suggested by Coyle et al., (2010) consists of 4 dimensions: Content, Communication, Cognition, and Culture. Content refers to the subject knowledge, communication refers to interactions in the teaching and learning process, cognition refers to the process of learning and thinking process, and culture refers to understanding of various cultures and global awareness after learning. Borrowing the successful experiences from Hong Kong (Tsang, 2020), vocabulary items and sentence patterns with existing Hong Kong and Taiwan chemistry curricula was carefully mapped. It was believed that content and language integrated learning helped to increase students' academic literacy in chemistry. In this study, vocabulary acquisition and sentence production in explaining phenomena was investigated.

There are numerous studies on EMI education in Taiwan in English teaching and learning, particularly in a high school context (Huang, 2020; Tsui, 2017) as the English proficiency of students are expected to be adequate enough to learn English through English. However, when students learn content subject using English, they need to focus on both content subject knowledge and English language, which might be difficult to students. Therefore, ample language support was provided to increase students' confidence in learning to cope with the language problem when they first learned Chemistry in English. Therefore, content and language integrated learning (CLIL) seems to be a solution for EFL students.

Theoretical framework

This study shows how students acquire the target chemical concepts in English using various methods. Lin (2016) demonstrated bridging between students' first language (L1) and the target language (L2) in Figure 1 by using a 'rainbow diagram'.

Figure 1

'Rainbow diagram' (Lin, 2016)

The 'rainbow diagram' was used in this study as it comprehensively shows the dynamics between L1 and L2 in various classroom contexts. For example, through careful translanguaging pedagogies, teachers can help bridge from L1 vocabulary items to the target L2 ones. Another example is using simpler L2 words to build complex L2 concepts through literate talk. Other than using L1 and L2, it's important to appreciate the role of multimodalities, such as visuals, diagrams, or videos, in helping students understand concepts when they are different and explain abstract or unfamiliar concepts to students with words only. Their value in aiding understanding cannot be overstated.

When EMI teaching commonly uses L2 for communication between teachers and students, the use of L1 is often neglected. However, Lin (2016) commented that the use of L1 should be minimised to maximise the exposure of L2 in a CLIL context; the use of L1 was beneficial in language learning (Lin, 2016). Therefore, the strategic use of L1 is necessary. In this study, the written academic register of L1 was used for direct translation from the textbook to the target language in class. As the study progressed, this L1 support was gradually removed, a transition that reassures us of the effectiveness of the approach, to lower Chinese reliance in a CLIL classroom. Instead, L2 support of daily language and oral academic language was used to scaffold students' learning of the target written academic language of L2. Throughout the study period, multimodalities, such as diagrams, were provided to students to help them understand the target written academic language of L2. It serves as the compromise between using students' schemata in L1 in teaching and learning while expanding the L2 language repertoire in the CLIL context.

Methodology

Research design

Programme chosen between content and language needs

Lin (2016) summarised various programmes based on content and language-driven programme learning goals and syllabuses. It was initially planned to be lessons for language for academic purposes to introduce chemistry terminologies and sentence patterns to explain certain chemistry phenomena. However, if the programme was like this, it would not be naturalistic and could not reflect the reality of CLIL classrooms; any limitations when CLIL teaching is implemented in content subjects may not be investigated for further improvement. Therefore, the focus of the study has been shifted to content-driven to show the actuality of a CLIL classroom for teachers and students. Explicit content and language objectives address this programme and language needs of the CLIL bridging pedagogies, modelling and practices; students are scaffolded to the target content and language. Therefore, this study employed immersion with language across the curriculum (LAC) to enrich students' English learning atmosphere. Coincidently, there was a COVID-19 pandemic during the study period. Therefore, the LAC course was conducted online.

Compared with other research designs, action research is an effective method of keeping the classroom naturalistic (Burns, 2009). Also, the topics involved in this study have little relationship with students' schemata; a pre-test seems impractical. Therefore, action research, instead of experimental research, was carried out.

Before teaching, the Hong Kong teacher-researcher collaborated with the Taiwan teacher to plan seamless teaching and learning between the conventional chemistry classroom and the LAC adjunct course in the planning stage. We needed to address the students' problems in learning chemistry in Chinese and English. Next, the teacher-researcher implemented the teaching schedule. Students were expected to understand and apply certain chemistry concepts, such as how to monitor the rate of reactions or how dynamic equilibrium is achieved. Moreover, students were expected to know how to calculate mathematical problems in a chemistry context, like using the Arrhenius equation to find out activation energy. Other than the content learning objectives, students were expected to learn how to write accurately in vocabulary and sentence levels. Details are shown in Table 1. After teaching, students had to undertake assessments to evaluate the effectiveness of CLIL teaching and learning. Finally, the teachers involved reflect the significance of the study.

Table 1

Scheme of work in this study

Lesson	Topic	Content Objectives	Language Objectives	
			Vocabulary	Sentence Language Functions
1	How to determine rate?	Calculate the rate of reaction	Rate of consumption Rate of production	
2	Methods to monitor the rate of reaction	Name the methods to monitor the rate of reaction with explanations	Colour change Colorimetry Precipitation reaction The change of volume / pressure / mass / pH / electrical conductivity of the system	Explanation
3	Order of reactions	Calculate the order of reaction	Order of reaction Rate constant	
4	Arrhenius equation	Calculate the activation energy by using Arrhenius equation	Activation energy	

Table 1 (cont'd)

Lesson	Topic	Content Objectives	Language Objectives	
			Vocabulary	Sentence Language Functions
5	Types of the order of reactions	Name the types of the order of reactions with explanation	Rate-concentration graph Concentration-time graph Half-life Zeroth / First / Second order reaction	Explanation
6	Factors affecting the rate of reaction	Explain factors affecting the rate of reaction by simple collision theory	Concentration Pressure Surface area Temperature Simple collision theory Kinetic energy Effective collisions	Explanation

Table 1 (cont'd)

Lesson	Topic	Content Objectives	Language Objectives	
			Vocabulary	Sentence Language Functions
7	Types of reactions and reaction systems	Name the types of reactions and reaction systems	Irreversible / reversible reactions Closed / open system	
8	Feature of dynamic equilibrium	Describe the features of dynamic equilibrium	Forward / backward reactions	Description
9	How concentration affects equilibrium	Explain how concentration affects equilibrium	Equilibrium position	Explanation
10	How pressure affects equilibrium	Explain how pressure affects equilibrium	Number of moles of reactants / products	Explanation
11	How temperature affects equilibrium	Explain how temperature affects equilibrium	Equilibrium constant	Explanation

Research Setting and Participants

Participants were drawn from Grade 10 students (n = 29) aged 15 to 16 in a public senior high school in Taiwan who received 11 online LAC adjunct lessons with rich language support of CLIL pedagogies. In addition to students, one Hong Kong chemistry teacher was also involved in investigating the perception of CLIL learning and teaching strategies.

Bridging pedagogies of a classroom with rich language support

Although the participants were in the elite class, they may not have been accustomed to a sudden change in the medium of instruction. Therefore, Lin (2016) and Lyster (2012) suggested that some bridging pedagogies were employed to relieve students' pressure when they suddenly had a CLIL class.

Code-switching between Chinese and English

In this study period, LAC adjunct classes were held for the participants as they encountered some abstract chemical concepts in formal lesson time. Therefore, these words were introduced with a Chinese translation that was near the English vocabulary, for example, chemical kinetics (化學動力學) and equilibrium position (平衡位置). This support through Chinese translations was provided to reassure you and alleviate any anxiety about learning Chemistry in English.

Promoting literate talk

Some subject-specific vocabulary can be explained from students' schemata as they learned English words in English lessons for daily scenarios. For instance, when a teacher-researcher explained the meaning of 'rate of reaction':

We would like to know something about the rate of reaction, but you may wonder, 'ah? What is the rate of reaction?' So, let us start with something more general first. Actually, we would like to know something, ah, some reactions, which one is faster, which one is slower. So, actually, we would like to know how fast is the reaction (the reaction is). So, we would like to know something about the speed of reaction. However, when we talk about the speed of reaction, it is too general, not scientific enough. So, we tend to talk about the rate of reaction.

The teacher-researcher started introducing the term rate of reaction by words they have learnt in English lessons (which is faster, which one is slower). Then, he summarised the phrase as 'how fast the reaction'. He used a more technical term, 'the speed of reaction', but he emphasised that it was not a term that should be used in the high school chemistry context.

He used 45 seconds to introduce the term 'rate of reaction' from daily oral language to oral and written academic language.

Using diagrams as multimodalities

When students learned about experimental set-ups used to monitor the rate of reaction, they were already equipped with the relevant chemistry concepts from their formal lessons. These lessons had prepared them well, making the diagrams describing the experimental set-up a seamless bridge between their prior knowledge in Chinese and the new knowledge in English.

Methods of data collection and analysis

Questionnaires

The primary purpose of the questionnaires was to examine the participants' attitudes, which echoes one of the research questions – students' perceptions of chemistry learning using the CLIL approach. Students were asked to rate their attitudes and perceptions using a 5-point Likert scale, and they were required to write short answers about their opinions and recommendations for CLIL chemistry learning to promote a more democratic classroom (Braden et al., 2016). Therefore, the research design called for the use of semi-structured questionnaires, a thoughtful choice that allowed for a more comprehensive understanding of the participants' perspectives. The responses collected after lessons have been summarized.

Assessments

The primary purpose of assessments is to examine how much students received in the courses, which echoes one of the research questions - the extent of effectiveness in learning subject-specific vocabulary and explaining scientific phenomena using English as a medium of instruction. Assessments were divided into two types – formative and summative assessments. Participants received formative assessments after CLIL lessons to evaluate how much they understood the lessons. A summative assessment was assigned in an examination period. When the research is involved in examinations, it may pose ethical concerns as it may pressure students. Therefore, this part serves as the bonus part in the examination component, and students can choose whether they attempt to eradicate any ethical questions. In these assessments, multiple-choice and short questions were used. The rationale was to examine whether students can receive and produce English in Chemistry. In other words, the various question types were used to examine students' receptive and productive skills in CALP. The researcher marked the assessment scores with a marking scheme with the content marks and language marks compared to the average marks and two-sample t-tests.

Observation

Classroom observations were employed to increase the amount of research data by recording the time of events and lesson context in detail. Triangulating the assessment and the questionnaire results provided a more holistic study picture.

Regarding the type of observations, the lessons were planned, and the focus of the observation about the use of teaching content and language parts of the chemistry lessons was known before the study. Moreover, the researcher aimed to understand if CLIL instruction enhances students' language awareness in CALP. Furthermore, the observer was also a teacher-researcher in the lesson, actively participating in observation. The observations recorded in this study were structured with full participation. Throughout the study of 11 weeks, lessons were videotaped, transcribed and analysed for content-language relationship.

Ethical Considerations

Classroom observations were employed to increase the amount of research data by recording the time of events and lesson context in detail. This, combined with the triangulation of the assessment and the questionnaire results, provided a more holistic and comprehensive study picture. This approach was designed to increase the generalisability in the thoroughness of the research.

When it came to the type of observations, the lessons were planned, and the focus of the observation about the use of teaching content and language parts of the chemistry lessons was known before the study. The researcher, not content to be a passive observer, actively participated in the lesson as a teacher-researcher. This active role was crucial in testing the hypothesis: 'CLIL instruction enhances students' language awareness in CALP'. The observations recorded in this study were structured with full participation. Throughout the study of 11 weeks, lessons were videotaped, transcribed and analysed for content-language relationship.

Results

Classroom observations

After transcribing the video recording, the transcript was analysed based on the teacher's talk on content and language, as tabulated below in Table 2.

Table 2

% of language emphasis in lessons

Lesson	Lesson Time (s)	Language	Language part (s)	Details	% language in lessons
1	1127	03:13 - 04:19	67		5.9%
		01:11 - 01:39	28	everyday to academic	
	775	03:20 - 03:45	25		6.8%
3	677		0		0.0%
		01:59 - 02:11	12	oral to written	
4	908	09:44 - 11:06	82	language to numbers	10.4%
5	728	04:48 - 05:35	47	numbers to language	6.5%
		01:24 - 02:33	69	oral to written	
		02:33 - 04:55	142		
		05:03 - 05:17	14		
		05:38 - 06:08	90	diagram to language	
6	665	06:46 - 08:54	128	numbers to language	66.6%

Table 2 (cont'd)

Lesson	Lesson Time (s)	Language	Language part (s)	Details	% language in lessons
		01:32 - 01:35	3	symbols to language	
		02:08 - 02:11	3	symbols to language	
		03:19 - 03:53	34	symbols to language	
		04:03 - 04:36	33	oral to written	
7	395	05:05 - 05:54	49	oral to written	30.9%
		01:13 - 03:34	141	numbers to language	
8	410	03:35 - 04:31	66	diagram to language	50.5%
9	922	03:16 - 06:21	185	everyday to academic	20.1%
10 - 11	897		0		0.0%
Total	7504		1218		16.2%

The details of the recordings which emphasised language objectives are as follows:

From everyday language to academic language

Some subject-specific vocabulary can be explained from students' schemata as they learned English words in English lessons for daily scenarios. The following is the teacher's spoken recap to students, explaining the 'rate of reaction' in lesson 1.

We would like to know something about the rate of reaction, but you may wonder, 'ah? What is the rate of reaction?' So, let us start with something more general first. Actually, we would like to know something, ah, some reactions, which one is faster, which one is slower. So, actually, we would like to know how fast is the reaction (the reaction is). So, we would like to know something about the speed of reaction. However, when we talk about the speed of reaction, it is too general, not scientific enough. So, we tend to talk about the rate of reaction.

It was observed that the teacher-researcher started introducing the target word 'rate of reaction'. Next, the researcher scaffolded students with everyday language 'which one is faster, which one is slower' that they learnt in English lessons in the past. Then, he summarized the everyday language term with another one, 'how fast the reaction'. After that, he removed the everyday language scaffold to academic language. He used an oral academic term, 'the speed of reaction,' to note the student to be back to the science context, but he emphasized that it was not a term that should be used in a high school chemistry context. Therefore, he reinforced students with the term 'rate of reaction' to replace their schemata' speed of reaction'. In 45 seconds, it is easy to observe the transition from introducing written academic language to daily oral language by increasing scaffolding; then, the scaffolds were gradually removed from everyday oral language to oral academic language and then to written academic language.

From oral academic language to written academic language

Some subject-specific vocabulary can be explained from students' schemata as they learned English words in this Chemistry course this semester. The following is the explanation of 'effective collisions'.

So what is simple collision theory? Actually, it is used to explain how a chemical reaction occurs. First of all, we know that for reactant molecules, they should have sufficient K.E., sufficient kinetic energy to overcome the activation energy. If they do not have enough kinetic energy, the reaction cannot start. The reaction cannot occur. So, the first factor for the *chemical reaction to occur – it should be energy. It should have sufficient kinetic energy. Other than that, even it have enough energy, it does not mean anything because we still have another point. The reactant molecules should collide in the same orientation. First of all, what is the meaning of 'collide'? The meaning 'bombard'. You may wonder, ah, what is the meaning of 'bombard'? Ok, I will show the diagram to you. And then for orientation, orientation is another word for direction.*

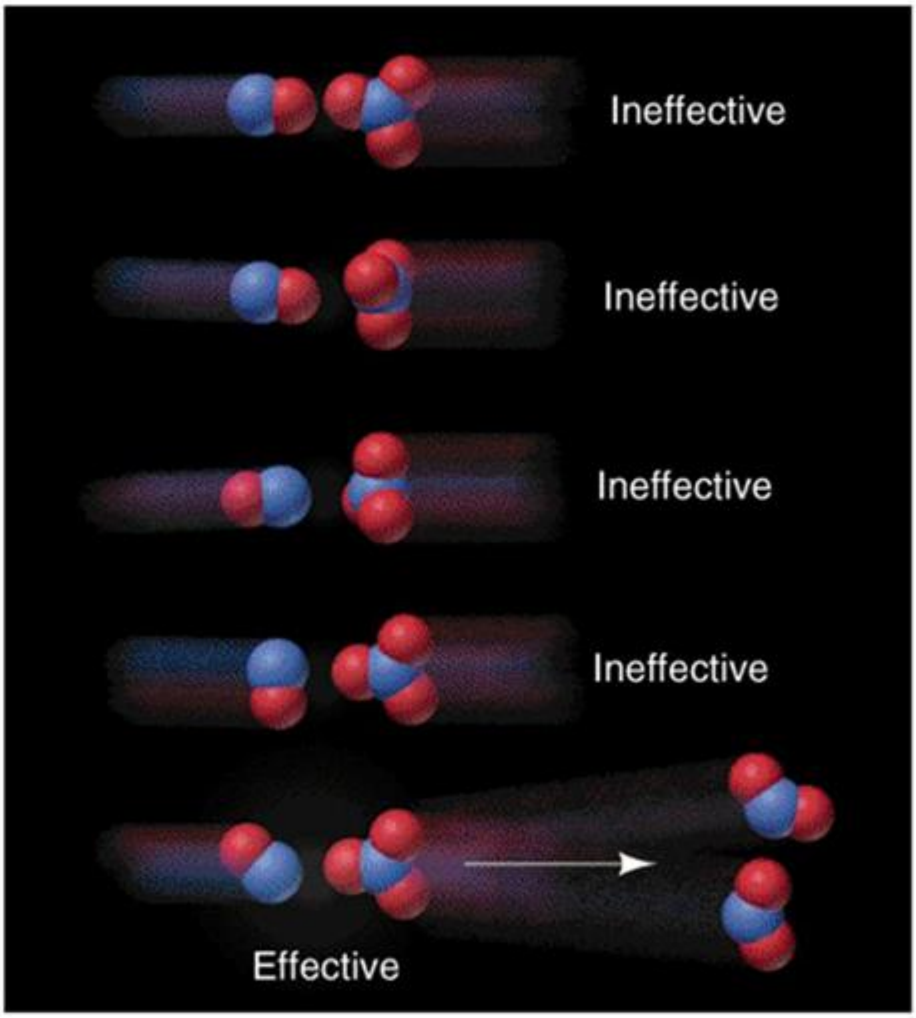
The main theme of the above explanation is to illustrate the two factors of effective collision – energy and orientation. It's important to note that most of the terms used are academic vocabulary, such as kinetic energy, activation energy, collide, and orientation. When the teacher-researcher realized that the term 'orientation' might be too complex for students, he promptly provided additional language support by introducing the everyday term 'direction'. This emphasis on the main theme will help students remember the key concept.

From a diagram to written academic language

In the above transcript, the teacher-researcher found it difficult to explain the word collide at that moment. Therefore, the teacher-researcher changed his strategy from explaining words by words to explaining words by diagrams, as shown in Figure 2.

Figure 2

Illustration of effective collision (Chang, 2008).



Explaining to students the meaning of colliding using a diagram is more precise than using another synonym.

From numbers to written academic language

Besides using a diagram, it is easy and convenient to explain a concept using numbers. For example, when the teacher-researcher is explaining 'half-life'. He showed the concentration-time graph clearly indicating the decrease of reactants: ' when a reactant is decreased to half, say from 0.2M to 0.1M, the time required is half-life.’ He then reinforced this concept by the time required to decrease the concentration from 0.1M to 0.05 M, a significant point as it marks another half-life. Consequently, numbers serve as good sources for explaining abstract terms.

The ratio between content and language emphasis in LAC adjunct course

The study involved an LAC adjunct course, so language emphasis was involved throughout the course. After transcript analysis, it was discovered that a small percentage of time was used as a language emphasis on sentence construction or vocabulary acquisition through literate talk and multimodalities. It was observed that a small percentage of time was used on language emphasis with variations. In the sixth and eighth lessons, more time was used for language emphasis to explain abstract concepts. In the ninth lesson, relatively more time was allocated for sentence construction. However, not much time was used for language emphasis throughout the lesson.

Questionnaire results

The questionnaire results are shown in Table 3. Participants generally had positive attitudes toward using CLIL pedagogies. After summarizing students’ responses to their perceptions of various CLIL approaches, over 75% strongly agreed or agreed that CLIL pedagogies could help them understand academic vocabulary in Chemistry.

Table 3

Questionnaire results on students' perceptions of CLIL

I can understand words using	% agree
multimodalities	95.0
literate talk	79.3
code-switching	75.3

Assessment results

Calculation questions

Most participants know how to calculate the questions involved in the programme. The percentage of correct answers in the first question was lower than in other questions. The reason is that students were unaware of the requirement of '1 mark' in Hong Kong, including calculation steps and the final answer. However, a '1 mark' is awarded when students answer one multiple-choice answer with one correct answer correctly. When students are asked to write, more than one mark is awarded, even if they write a single word. After clarifying the answers' requirements, the participants' performance increased. The result is shown in Table 4.

Table 4

Students' results on calculations

Question	% of accuracy
Calculation on rates	55
Calculation on the order of reaction	79
Calculation on Arrhenius equation	60

Short questions

Other than examining participants' receptive skills, their productive skills were also assessed. The following table shows the results of participants when they answered various types of questions summarized by language functions. The result is shown in Table 5.

Table 5

Students' results on short questions

Language function	Question	% of accuracy
Word	Name a method to monitor the rate of reaction	32.40
Sentence	Determine the order of reaction with explanation	51
	Explain the relationship between temperature and rate	60.33
Academic function	Definition of activation energy	80
	State the features of dynamic equilibrium	58

Students needed to be stronger in naming a method to monitor the reaction rate. The following is an excerpt of their work.

Question: Name a method to monitor the rate of reaction.

Students' answer: by measuring pH

Correct answer: by measuring pH ***change***

Most students did not seem aware of the word 'change'. Instead, they just wrote down 'pH'. In other words, students were unaware of the difference between 'pH' and 'pH change', while ‘pH’ is a subject-specific word in chemistry. In contrast, the word ‘change’ is a general academic word; it can be observed that participants were not that aware of general academic vocabulary at first. However, when immersed in the CLIL context, they generally coped with this situation. When students were asked for a more complex answer, for instance, writing a sentence and academic function, over half of the participants answered sentences and academic functions correctly.

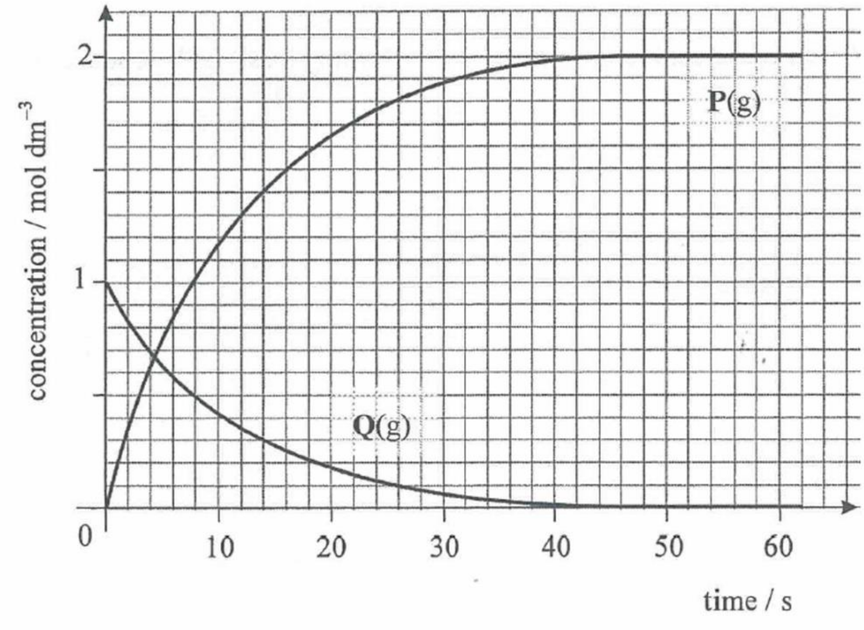
Comparison between Taiwan and Hong Kong students

One multiple-choice question was taken from the university entrance examination in Hong Kong (Hong Kong Diploma of Secondary Education Examination (HKDSE)) in 2012 to compare students’ abilities in Taiwan and Hong Kong. The question is as follows in Figure 3:

Figure 3

The question which was used to compare Taiwan students' ability with Hong Kong counterparts (HKEAA, 2012)

The concentration-time graph for a certain chemical reaction in a closed vessel of a fixed volume is shown below:



Which of the following chemical equations correctly represents the reaction?

A. **P** (g) → **Q** (g)
B. **Q** (g) → **P** (g)
C. **P** (g) → 2**Q** (g)
D. **Q** (g) → 2**P** (g)

83% of the participants answered this multiple-choice question correctly, while 88% of the HKDSE participants answered it correctly. That means their performances are comparable.

Comparison between English and Chinese paper

In this assessment, one question was set up with both Chinese and English versions, which aimed to investigate the difference in academic achievements when students were asked to read questions in different languages and produce the same type of answer. This question, as indicated in Figure 4, asked students to find out the rate of disappearance of one chemical in English and Chinese.

Figure 4

Various versions of questions for the same concept written in (a) English; and (b) Chinese

(a)

Permanganate ions (MnO_4^-) is a suitable chemical to determine the content of iron (II) ions (Fe^{2+} (aq)) in an iron tablet. Before investigating the amount of iron, a student would like to investigate the chemical kinetics of the following reaction:

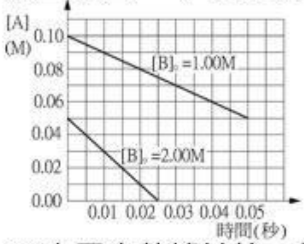
$5Fe^{2+}$ (aq) + MnO_4^- (aq) + $8H^+$ (aq) → $5Fe^{3+}$ (aq) + Mn^{2+} (aq) + $4H_2O$ (l)

(2) If the rate of production of Fe^{3+} (aq) is 0.01M/s, calculate the rate of disappearance of MnO_4^-(aq).

(1 mark)

(b)

（二）某生為了解反應2 A＋B → C＋D的反應速率，在25 °C下，做了兩個測定反應速率的實驗，每實驗所配之A與B的初始濃度（分別以$[A]_0$及$[B]_0$表示）都不同，下圖為所測得之A濃度隨時間的變化，此兩實驗所用的濃度$[B]_0$遠大於$[A]_0$。試回答下列的問題：（每題需詳列計算過程，除(2)外，**<u>所有答案必須附上單位</u>**）**（每格2分，共12分）**



(1)由圖中數據計算，當$[B]_0$＝1.00M及$[B]_0$＝2.00M時，A的初始消失速率分別為______和______。

(2)由圖中數據判斷，此反應的速率表示法為______。此反應的反應級數為______。

(3)由A的消失速率計算反應速率常數為______。

(4)在25 °C下，當[A]＝0.08 M，[B]＝0.10 M時，A的消失速率為______。

Before the assessment, it was expected that students would perform better in the Chinese question than in the English one. However, to our surprise, students answered the English questions better than the Chinese ones. 66% of students answered the English question correctly, while only 22% answered the Chinese question. This unexpected outcome prompts further investigation into the factors influencing students' performance.

Two sample t-tests, as indicated in Table 6, were conducted to explore the impact of language on students' results. The findings are of significant importance, as they reveal a strong relationship (p <.001) between language and students' performance. This underscores the fact that language is not a dominant factor in students' results, a key insight from our study.

Table 6

Two sample t-test result

Sample mean (n = 29)	0.224	0.655
Standard derivation	0.484	0.413
	***p < .001	

Discussion and Implications

Implications from the results

Overall, participants demonstrated a commendable grasp of receptive skills in recalling chemistry terminologies when performing calculations in chemistry. It was observed that students required time to acclimate to the CLIL learning environment. However, once they became familiar with the CLIL context, their performance was satisfactory, particularly when the lexical density of the question was reduced with adequate scaffolding in lessons. Notably, Taiwanese students showed the potential to perform on par with their Hong Kong counterparts in a CLIL learning environment. This highlights the urgent need for educators to invest in students' familiarization of the CLIL teaching and learning environment, and to consider the benefits of bilingual education.

The ‘fluidity’ of the teacher identity

In this research, the teacher-researcher demonstrated how the language part of the LAC adjunct course varied in lessons. When students did not have adequate schemata, the teacher-researcher needed to explain to students by literate talk. Some Taiwanese teachers might be scared about this approach as it wastes much time before returning to the academic context. Although more than half of the lesson time was spent in the CLIL approach in two lessons, less than 20% was utilized to support students in academic written language. That means the CLIL approach was still supportive; it did not override the authentic curriculum. Moreover, after observing promising students’ academic performance in the assessments, the CLIL approach was an ‘investment’ to students instead of a waste of teaching time.

Bilingual Education in Taiwan

When discussing bilingual education in Taiwan, many Taiwanese teachers are worried about the delivery of lessons and assessments. In this study, it could be observed that the teacher-researcher did not produce perfect grammar, and he might not have delivered every concept concisely – he still needed some thinking time, which was normal for a non-native speaker.

Nevertheless, students could still produce satisfactory results despite the teacher-researchers minor tweaks in lesson delivery. Therefore, Taiwan teachers can treat this study as an example – content subject teachers' English standards might not be very high. However, they should be able to deliver what they want to teach in lessons using adequate English. With the surprising comparison between English and Chinese questions in the assessment, it can be observed that careful control of lexical density is one of the essential factors of students' satisfactory results. Once students understand what a teacher asks, they can answer with the correct approach. Therefore, it is suggested that the lexical density of assessments should not be too complex. When assessments are written in simple English, students can understand assessment questions. Eventually, the CLIL context will not burden Taiwan students in learning content subjects.

Limitations

This action research was taken in an elite class of a senior secondary school in Taipei. The sample size was not that large. Moreover, because of the pandemic, the time of this study was limited. In this case, the teacher-researcher could not run another round of the research cycle. However, as the questionnaire results, assessment results, and lesson recordings were highly triangulated, the results are highly correlated. Therefore, this study still has a high level of generalizability and trustworthiness.

Conclusion

Hong Kong and Taiwan teachers developed an LAC adjunct course that suits the Taiwan context using relevant CLIL pedagogies as students' language support. Students generally had positive attitudes toward the CLIL approach, even if they needed to study in an unfamiliar CLIL context. Moreover, they performed satisfactorily in assessments. That means most of them could acquire CALP at word and sentence level in a Chemistry classroom in the CLIL context. However, due to the class size and the time limit, the teaching and learning effectiveness cannot be reproduced at this moment. However, there will be more and more studies about CLIL pedagogies in Taiwan that can further reproduce the findings of this study.

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摘要

隨著 2018 年新課程改革的實施，台灣教育部建議學生不僅要使用英語進行人際交流，還要與其他內容學科領域交流。然而，教育工作者和研究人員需要更關注以英語作為外語的學習者（EFL 學習者）學習內容科目（例如科學）的問題。因此，對於大多數仍然是英語學習者的台灣學生來說，強大的語言支援，例如內容和語言整合學習（CLIL）方法下的支援，不僅是必要的，而且也是有作為的。這種方法可以使用英語作為教學媒介 (EMI) 顯著增強他們對複雜化學知識的理解。本研究的中心論點是學生在化學課堂上高認知需求的豐富語言支持課堂環境中的表現。本研究旨在監察學生的學習進度，以評估 CLIL 在化學動力學和動態平衡學 2 個月的學與教中的潛在成效。研究問題包括學生在詞彙和句子層面知識獲取程度以及教師和學生對 CLIL 教學的看法。

這項行動研究由 29 名學生組成，首先透過 10 年級化學課中的 CLIL 橋接教學法（Lin，2016）進行內容和語言教學。然後使用 t 檢定對學生延遲後測進行定量分析，為他們的學習成果提供可靠的衡量標準。此外，對口頭和書面語進行定性分析，以確

定教師在認知領域使用 CLIL 進行教學和學習的有效性。這種全面的方法可確保全面了解 CLIL 對學生和教師的影響。此外，研究利用半結構式問卷來了解學生在 CLIL 教學後的態度。我們將詳細討論這項研究的教學和實證意義，讓台灣教育工作者全面了解 CLIL 在內容課程中的好處。