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Building in language support in a Hong Kong CLIL chemistry classroom: An exploratory study

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Abstract
Science writing has played a crucial part in science assessments. This paper reports a study in an area that has received little research attention – how science lessons in content and language integrated learning (CLIL) can increase the science knowledge development of English as a foreign language (EFL) students in Hong Kong. The data come from a school-based interventional study in chemistry classrooms, with written data from questionnaires, assessments and teachers' logs and verbal data from interviews and classroom observations. The effectiveness of the CLIL teaching and learning activities in various chemistry classrooms were compared and evaluated, with a discussion of some implications. The paper concludes that CLIL teaching and learning activities yielded positive learning outcomes among chemistry learners with low English ability.

Keywords: content and language integrated learning (CLIL), English as a foreign language (EFL), chemistry teaching

1. Introduction

There have been several transitions in language policy in Hong Kong – from non-intervention in the British colonial period to streaming students to study in secondary schools with Chinese Medium of Instruction (CMI) or English Medium of Instruction (EMI) schools implemented in 1998. However, the strong labelling effect of EMI schools being perceived as first-rate and their CMI counterparts regarded as second class (Tung, Lam and Tsang, 1997) fostered a modification of language policy. According to the 'Fine-tuning the Medium of Instruction for Secondary Schools' policy implemented in 2009, secondary schools enjoyed more autonomy in choosing the medium of instruction for their teaching and learning activities (Education Bureau, 2009). Since then, there has been an increasing number of secondary schools switching their medium of instruction. Teaching content subjects through English has become more and more prevalent. However, social and psychological problems of learning through English, mainly the shift from Chinese medium to English medium, have been occurring (Poon et al., 2013). Since CLIL programmes prioritise language scaffolding, it is advisable to use CLIL teaching and learning strategies to build sufficient language support to foster students' learning with a lower language burden (Van de Craen et al., 2007).

There are many research papers concerning chemistry writing activities for students who are English natives, i.e. ENL students (Beall, 1998; Cooper, 1993; Glynn and Muth, 1994; Johnstone, 1997; Keys, 1999; Knipper and Duggan, 2006; Rivard, 1994; Yore, 2000) or students using English as a second language, i.e. ESL students (Wellington and Osborne, 2001), but few studies have investigated students who use English as a foreign language in a non-English-speaking context, i.e. EFL students. Doing research on EFL students in a subject-based context is more challenging as students need to overcome not only the content knowledge barrier but also the language barrier. They need to translate what they have learnt in English to their L1 for practical storage as long term memory. This translation step adds to the complexity of the research. Therefore, it is not common to find journal articles concerning chemistry learning for EFL students. However, there are many EFL students in the world learning content subjects, especially science subjects, in English. Therefore, research gaps appear. There are few studies on science writing, and there are scarce studies on the integration of science and language learning in the Hong Kong context. Two research questions arose: what are teachers' and students' perceptions of chemistry learning using the CLIL approach and how students' content and language awareness changed after intervention in CLIL lessons. This study serves as a first in-depth investigation of how EFL students learn chemistry in a non-Anglophone context (Hong Kong) through the analysis of a teaching and learning cycle in a chemistry classroom.

Therefore, the effectiveness of the implementation of using teaching and learning cycle in a chemistry classroom was evaluated.

2. Theoretical framework: Teaching and Learning Cycle

Science teachers in Hong Kong are too concentrated on teaching content knowledge, with little concern for language needs. Content and language integrated learning has been used for effective teaching in content subjects using English as a foreign language.

Lin (2015) demonstrated the enrichment of context by using multimodalities such as adding digitals and visuals to lessons before language support as suggested by Rose and Martin (2012). Teachers need to break down information into meaningful parts (such as subject-specific vocabulary, general academic vocabulary and signalling words) for students by deconstruction. Then, in the third step of this curriculum cycle, teachers and students work together to build a coherent text in joint construction based on what students have learnt and content support and language support from teachers. Finally, students have to work on a text on their own to determine the lesson outcomes. Moreover, Derewianka (2003) suggested that follow-up tasks, also called parallel tasks, should be introduced into the teaching and learning cycle to check students' understanding. The teaching and learning cycle should be modified as follows.

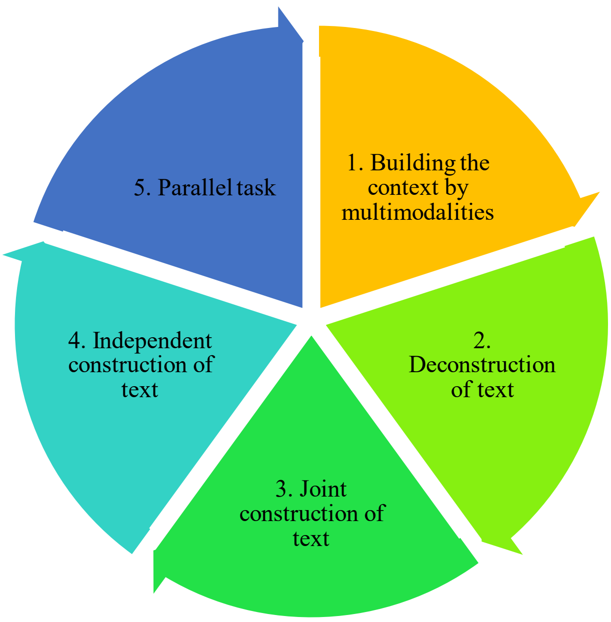

Figure 1. Multimodalities and Entextualization Cycle (Lin, 2015)

Despite adjustments, using the teaching and learning cycle is popular in ESL curricula, such as in Australia (Derewianka, 2012). In Hong Kong, EFL learners are the majority, but there is little progress to be found in implementing content and language integrated learning (CLIL). Therefore, this study serves as a pilot to evaluate the effectiveness of using the teaching and learning cycle, modified from an ESL context to an EFL classroom.

3. Literature Review

3.1 Writing in Science

3.1.1 *The importance of science writing*

In recent decades there has been a wide range of studies on how to promote academic literacy in science (e.g. Connolly, 1989; Cooper, 1993). Yore et al. (2003) commented that there had been many studies of science teaching promoting the experimental approach and criticizing the use of written media such as textbooks to learn science. Comparing hands-on experiments with printed media, Yore concluded that the experimental approach is not as practical as the language input to students was limited.

Promoting academic literacy in science is all the more essential as laboratory skills alone cannot reflect students' learning outcomes, which are better reflected through speaking and writing. Therefore, compared with laboratory skills, developing students' productive academic literacy skills should come first. In the educational context in Hong Kong, science writing is of particular importance as writing is related mainly to students' assessment, both formative and summative. In other words, teaching students how to write science contributes significantly to students' learning. Studies in science writing should occupy an integral part of science education, according to Yore, but studies related to science writing are relatively rare because of difficulties in proving whether students' writing is authentic. The authenticity of students' progress lowers the validity of the results as students may plagiarize from other students' work. Therefore, in this study, lesson time was devoted to allowing students to write, in order to ensure every piece of writing was genuine for this investigation.

3.1.2 *Science Knowledge Acquisition of EFL students*

Language adds difficulty to science knowledge acquisition among EFL students.

According to the information processing model developed by Johnstone (1997) as can be seen in Figure 2, students perceive stimuli according to various events, observations and instructions. Then, students filter what they perceive using their perception filter. After that, the information is regarded as residing in working memory. It is a place for holding immediate ideas for further interpretation, rearrangement, comparison, storage and preparation to long-term memory. When information is stored as long-term memory, it can be retrieved when needed or further filtered by the perception filter in a feedback loop. The process can be simplified as an information processing model below.

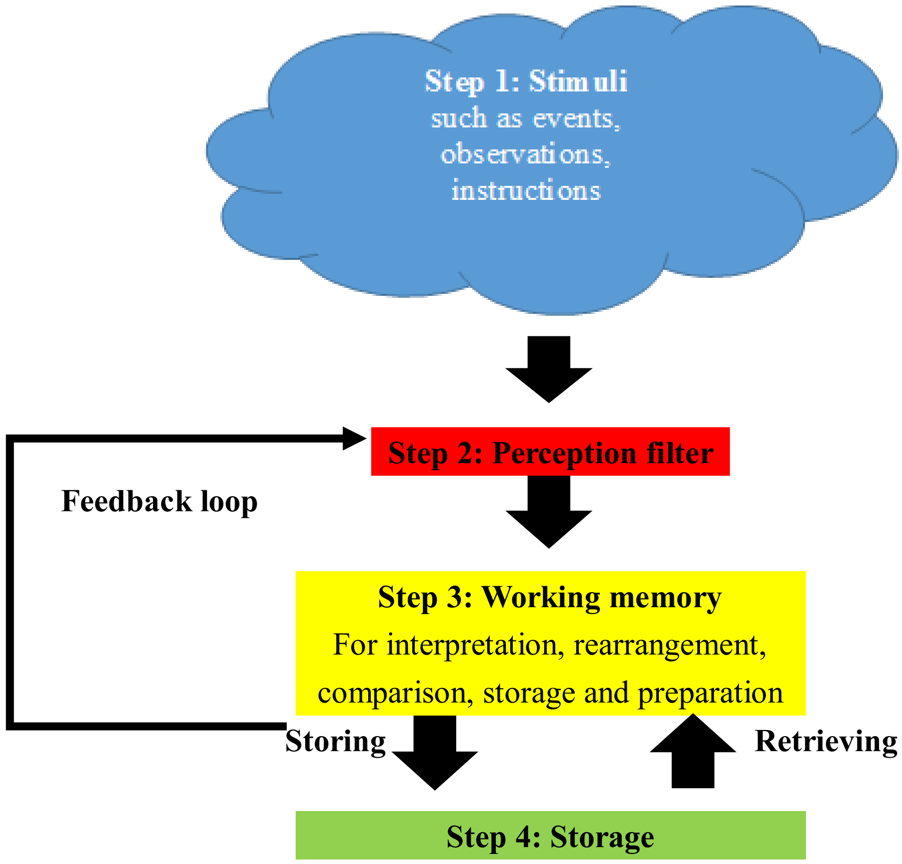

Figure 2. Information processing model (Johnstone 1997, p.263)

In working memory, students need to interpret information. However, as the information is written in English, extra time is needed to process information between English and L1 for EFL students, adding an extra burden to students' knowledge acquisition in science using the English medium of instruction. Moreover, the setting in an English-medium classroom resembles the settings for ENL or ESL learners, but EFL students have limited language resources. More time is needed for students to process the information both during and after lessons. Huang (2005) concluded that extra time spent on learning while using English for content subjects is caused by slow reading speeds, fast presentation of materials and insufficient comprehension time for English, adding an extra burden to students' knowledge acquisition in science using the English medium, which in turn lowers students' incentives to learn science.

In Hong Kong, most EFL students who are receiving English medium instruction (EMI) in content areas are high performing students who have high learning ability, especially in English. However, the English standard for primary students is Basic Interpretational Communication Skills (BICS), but not Cognitive Academic Language Proficiency (CALP), according to Cummins (2008). This means that primary students have a relatively high proficiency in BICS, but their CALP proficiency has yet to be developed. One of the major features of CALP is the presence of nominal groups at word level and nominalisation at the sentence level, based on the conclusions of Gibbons (2009). Students may perform well in English language lessons, but not so well in English-medium content lessons. They achieve excellent results in English, but they may not be able to get satisfactory results learning through English. When EFL students are first exposed to English in content lessons, it is normal for them to be used to mastering English with difficulty. However, when these potentially talented students are constantly facing challenges in the shape of cognitively-demanding and content-embedded tasks during lessons with insufficient language support, they may feel under undue pressure about learning through English and eventually lose interest in learning. Therefore, this study aimed to evaluate students' learning effectiveness of using the teaching and learning cycle in a CLIL context with EFL students.

3.2 Content and Language Integrated Learning

Ample language should be provided in order to increase students' confidence in learning to cope with the language problem in learning chemistry. Therefore, content and language integrated learning (CLIL) seems to be a solution to EFL students. Content and Language Integrated Learning was defined as 'a dual-focused educational approach in which an additional language is used for the learning and teaching of both content and language' (Coyle, Hood and Marsh, 2010). Borrowing the successful experiences from Sydney (Rose and Martin, 2012), with a careful mapping of genres with existing chemistry curriculum, it was believed that content and language integrated learning helped to increase students' academic literacy in chemistry.

3.3. 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 not explicitly targeted at chemistry, and those that do exist have focused on ENL or ESL students (Johnstone and Selepeng, 2001). For EFL students, many studies have been done on language acquisition (Coxhead, 2018), but not for content knowledge acquisition in chemistry. It is for this reason that the current study focuses on evaluating students' learning effectiveness in acquiring chemistry knowledge in a classroom using English as a teaching medium.

4. Methodology

4.1 Research design

Compared with other research designs, quasi-experimental research is a more effective method in many contexts. In this study, treatment groups received CLIL teaching while a control group received traditional science teaching with the same chemical knowledge delivered. The mode of teaching, one with more language support and the other with less, was the independent variable. The chemical knowledge delivered was the controlled variable. Tests assessed students' progress; their progress is the dependent variable.

The independent and dependent variables were manifest. With careful planning concerning the controlled variables, a stable cause-and-effect relationship of whether the CLIL learning and teaching method help to increase students' content and language awareness in chemistry was established.

Variable	**Details**
Independent	mode of teaching
Dependent	students' progress
Controlled	chemical knowledge delivered

Figure 3. Summary of the experimental research in this study

A quasi-experimental design was the most suitable for this study as there were control groups throughout the study, and it was unethical to randomize students based on their gender, ethnic or socioeconomic differences. Among experimental designs, this study resembles a pre-test post-test non-equivalent groups design; a brief scheme of work is shown below.

Stage of study	**Treatment group**	**Control group**
1	Pre-test 1	Pre-test 1
2	Treatment added	No treatment added

	(writing definitions)	
3	Post-test 1	Post-test 1
4	Pre-test 2	Pre-test 2
5	Treatment added (writing procedures)	No treatment added
6	Post-test 2	Post-test 2

Figure 4. Scheme of work in this study

Before teaching, a pre-test was carried out to identify the background knowledge of the students. Sentence-making tables were used as scaffolds in writing definitions, and the whole TLC cycle was implemented when teaching how to write procedures. After teaching, students had to undertake a post-test to measure the effectiveness of CLIL teaching and learning compared to the conventional method.

4.2 Research setting and Participants

Participants were drawn from Grade 10 and 11 (15 – 17 years old) students studying Chemistry in a Band 1 secondary school in Hong Kong. Participants were divided into two groups in each form, control group and treatment group, as follows:

	Treatment group	**Control group**
Grade 10	Elite class (30 students) [TG10]	Mainstream class (20 students) [CG10]
Grade 11	Mainstream class (20 students) [TG11]	Elite class (30 students) [CG11]

Figure 5. Scheme of work in this study

Other than students, chemistry teachers (n=2) were also involved in investigating the perception of CLIL learning and teaching strategies.

4.3 Methods of data collection and analysis

4.3.1 *Questionnaires*

The main purpose of questionnaires was to examine the attitudes of the participants 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 Likert scales, and they were required to write short answers about their opinions and recommendations to chemistry learning, in order to promote a more democratic classroom (Braden et al., 2016). Therefore, semi-structured questionnaires, instead of unstructured or structured ones, were used.

4.3.2 *Focus group interview*
Focus group interviews were needed to obtain follow-up responses based on the questionnaire results in order to enrich the research data. Moreover, the responses from focus group interviews enabled us to triangulate the results from the questionnaires, increasing internal validity. In this study, the interview required authentic responses. Moreover, not only the context, topic and issues but also the questions were set before the interview. As a result, standardized open-ended interviews were the technique of choice.

4.3.3 *Observations*
Classroom observations were employed in order to increase the amount of research data by recording the time of events and lesson context in detail, ultimately providing a more holistic picture for the study.

Regarding the type of observations, the lessons were planned, and the focus of the observation was clearly known before the study. Moreover, the researcher was aiming to test the hypothesis: 'CLIL teaching enhances the language awareness of students'. Furthermore, the observer was also a teacher-researcher in the lesson, taking an active role in observation. The observations recorded in this study were structured, with full participation. Throughout the period of study of 8 weeks, lessons were audiotaped, transcribed and analysed. In addition, the content of students' test papers was analysed for the content and language awareness of students, in order to answer another research question – whether students' content and language awareness changed after intervention in CLIL lessons.

4.4 Research Questions
1. What are teachers' and students' perceptions of chemistry learning using the CLIL approach?
2. How were students' content and language awareness changed after intervention in CLIL lessons?

4.5 Ethical Considerations
Informed consent was received from the students, parents and the Principal in order to guarantee students' privacy and their rights in the study period. A power relationship existed between the researcher and the participants, as the researcher was the teacher of the participants. The research process was democratised, and the power relationship was minimised. While students did not have a choice in teachers' lessons for learning or to withdraw from lessons, they were free to participate in the research aspects of

study and had the right to opt-out at any time. These measures were implemented in order to allow a smooth investigation and make participants feel at ease and comfortable.

5. Results

5.1 In the Pre-study Period

Results from questionnaires and focus group interviews

Students were asked to comment on the effectiveness of various teaching practices for enhancing academic performance. Conventional teaching methods, like teacher talk or group discussions, were not that popular among students in the treatment groups as can be seen in Figure 6. On the contrary, the results in Figure 7 show that multimodal activities, such as video-watching and performing experiments, were widely supported by students. Therefore, students do believe that learning activities greatly influence their academic performance.

Question		**Mean**
My marks will be higher if the lesson is conducted		
(a) only by teacher talk.	TG10 Elite	3.06
	TG11 Mainstream	3.30
(b) with group discussions between students.	TG10 Elite	2.97
	TG11Mainstream	3.20

Figure 6. Low ratings for conventional teaching pedagogies

Question		**Mean**
My marks will be higher if the lesson is conducted		
(a) with videos included.	TG10 Elite	3.72
	TG11 Mainstream	3.20
(b) with diagrams included.	TG10 Elite	4.03
	TG11 Mainstream	3.70
(c) with demonstration of experiments by teacher.	TG10 Elite	4.10
	TG11 Mainstream	3.60
(d) with individual experiments included.	TG10 Elite	3.91
	TG11 Mainstream	3.30
(e) with experiments in pairs or groups included.	TG10 Elite	3.97
	TG11 Mainstream	3.50

Figure 7. High ratings for multimodalities

Next, students were asked to comment on their acceptance of teaching methods, i.e. components of the teaching and learning cycle (Rose & Martin, 2012). In general, students did not reject innovative activities. The mainstream class welcomed activities where teachers and students write together, i.e. joint construction. However, they had some reservations about highlighting words in lessons, i.e. detailed reading in deconstruction. Moreover, students in elite classes hesitated to write on their own, i.e. independent construction. The reasons behind students' responses were investigated through focus group interviews.

Finally, students were requested to evaluate the effectiveness of different assessments. Generally, students believed that the suggested assessment methods were beneficial to them, especially doing supplementary exercises. Therefore, in this study, supplementary exercises were employed for the parallel tasks in the multimodalities and entextualization cycle (MEC) (Lin, 2015).

Towards the end of the questionnaire, the language awareness of students was assessed using a sample answer script which contained some language features at the word level with subject-specific vocabulary in bold, general academic vocabulary underlined and signalling words in italics, at the sentence level with imperatives, and at the text level concerning procedure. The underlying reason for setting up such a situation is that the teacher in lessons can tackle every difficulty indicated in this assessment. The situation was set up as follows:

Question: Suggest experimental steps for a flame test of sodium.
Answer:
Dip a **platinum wire** into **concentrated hydrochloric acid**. *Then*, dip the wire into a sample powder. *Finally*, heat the wire strongly with a **non-luminous flame**.

After the assessment (results shown in Figure 8), it can be concluded that elite class students were strong in subject-specific vocabulary and general academic vocabulary, but they had relatively lower awareness of signalling words. The mainstream class students had a relatively higher awareness of high-frequency words, particularly signalling words. However, they were relatively less aware of low-frequency subject-specific vocabulary items.

When it came to sentence-level patterns, elite class students had a higher awareness of using imperatives. At the text level, the groups showed little difference.

Question		Mean
Would you be confident in (a) using the following words or phrases correctly in your writing?		
i. **platinum wire**	TG10 Elite	4.27
	TG11 Mainstream	3.90
ii. **concentrated hydrochloric acid**	TG10 Elite	4.39
	TG11 Mainstream	4.60
iii. **non-luminous flame**	TG10 Elite	4.42
	TG11 Mainstream	3.50
iv. dip	TG10 Elite	4.33
	TG11 Mainstream	3.70
v. Heat	TG10 Elite	4.39
	TG11 Mainstream	4.50
vi. Then	TG10 Elite	3.73
	TG11 Mainstream	4.70
vii. Finally	TG10 Elite	3.73
	TG11 Mainstream	4.70
(b) using the sentence structure (using infinitive as a start of a sentence) correctly in your writing?	TG10 Elite	3.60
	TG11 Mainstream	4.20
(c) using a correct writing framework (i.e. text type) for your answer?	TG10 Elite	3.67
	TG11 Mainstream	3.70

Figure 8. Diverse ratings in language awareness at word level but higher ratings in language awareness at sentence and text level

When respondents had finished rating the aforementioned tasks, they were asked to express their concerns about challenges in learning chemistry. From the opinions of students, both content and language learning were a concern. Participants' responses about learning difficulties in chemistry content were quite individualized and topic-specific. However, their responses regarding language learning difficulties were quite consistent. Focusing on difficulties related to learning chemistry in English, most students stressed that there were challenges at the word level, including both subject-specific and general academic vocabulary items, from both productive and receptive points of view, which echoed with the responses from the focus interviews.

The following are some comments from the respondents:

Difficulties in learning Chemistry in English:

- I could not understand some words
- I often spell words wrongly
- There were too many technical terms
- I do not understand well in lessons conducted in English
- I do not know what the words in question mean
- I could not use suitable words to express my answer

5.2 During the Study Period

5.2.1 *The MEC*

Using teaching material from Grade 11 as an example, Grade 11 students were shown an experimental set-up to determine the enthalpy change of a reaction. This set-up has been used for a chapter opener in order to arouse the interest of students. After probing students about using that set-up to measure physical quantities for calculations, the preparation of such an experiment was investigated through the experimental procedure. Then, the procedure of determining enthalpy change was deconstructed from text level to word level. Students were told about the framework of constructing the procedure. Students were guided by detailed reading to focus on words which were crucial terms in a chemistry context (subject-specific vocabulary), and words which were not chemical terms but essential in building chemistry context (general academic vocabulary) using a top-down approach.

After the deconstruction of the text, subject-specific vocabulary items, general academic vocabulary items and connectives for time sequencing (signalling words) were not given. Students were asked to fill in the blanks from the words they had learnt. Once joint construction of text was done, students needed to write an experimental procedure on their own. That means they had to construct their own text. Finally, a parallel task with the same question type but differing slightly in question words was provided in order to check students' understanding.

5.2.2 *Student-and-Teacher Interactions*

At the beginning of the CLIL teaching, students tended to receive chemical knowledge solely from listening to teachers, in the same manner as when they were receiving non-CLIL teaching. High-achieving students, 25% of students, tended to ask questions for their satisfaction, but other students ignored the conversation as they believed this was not useful for their learning. However, when CLIL teaching was continuously employed, some low achievers raised queries concerning the construction of chemical knowledge for clarification. See the following.

Teacher: What is the meaning of ‘standard enthalpy change of combustion’?
High-achieving student: It is the energy change for 1 mole of substances burning completely under standard conditions.
Teacher: Exactly.
Lower-achieving student: Can I omit the word ‘completely’ in the exam? (Asking for clarification)
Teacher: Good question. Let me say it in another manner. For standard enthalpy change of combustion of graphite. If it is not burnt completely, will carbon dioxide be formed?
Middle-achieving student: No. Carbon monoxide, instead of carbon dioxide, is formed.
Teacher: So what is the meaning of putting ‘completely’ in this definition of ‘standard enthalpy change of combustion’?
Lower-achieving student: Safer. More secure. Don’t lose marks.
Middle-achieving student: To make a more complete definition.
Teacher: You got my point.

5.2.3 Pre-test

A pre-test was administered to diagnose the students' language difficulties more deeply. As the treatment group in Grade 10 was the elite class while the control group was the mainstream class, the average mark in the treatment group was still higher than that of the control group.

	Word	Equation	Definition	Essay	Effective communication mark
TG10	74%	90%	87%	53%	48%
CG10	50%	42%	50%	15%	0%

Figure 9. Performance in Grade 10 classes

As in Grade 10, a pre-test was administered to diagnose the language weakness of students more profoundly. As the treatment group in Grade 11 was the mainstream class while the control group was the elite class, the average mark in the treatment group was lower than that of the control group.

	Word	Definition	Essay	Effective communication mark
TG11	50%	82%	27%	18%
CG11	56%	93%	62%	13%

Figure 10. Performance in Grade 11 classes

Before the CLIL teaching and learning activities, the errors made by students were quite diverse. They tended to produce vague and superficial answers. The following is a script from a Grade 10 student.

1. Calcium reacts with an acid to form an insoluble substance. Name the acid and write down a chemical equation involved.

(2 marks)

Hydrochloric acid.

[Teacher's comment: Wrong recalling of facts, 0 marks]

$Ca + 2HCl \rightarrow CaCl_2 + H_2$

2. What is a 'saturated solution'?

(1 mark)

A saturated solution is a solution which cannot dissolve any more solute.

[Teacher's comment: Not precise, 0 marks]

3. Describe how to prepare saturated calcium chloride solution in the laboratory under room conditions.

(5 marks*)

Add calcium metal with hydrochloric acid.
Filter the solid.
Saturated solution will be obtained.

[Teacher's comment: Incomplete procedure, 2 marks]

5.2.4 *Post-tests*

A post-test was designed to evaluate students' progress with or without CLIL teaching. The results in the treatment group with elite students were higher than those of the control group in the mainstream class. However, the difference in marks between the two groups was not significant after CLIL teaching. There was a dramatic increase in scoring for effective communication.

	Word	Equation	Definition	Essay	Effective communication mark
TG10	50%	46%	94%	68%	68%
CG10	42%	0%	75%	34%	29%

Figure 11. Performance in Grade 10 classes

As with Grade 10 students, a post-test was designed for the Grade 11 students to evaluate their progress as a result of CLIL teaching. The results for word questions in the treatment group were lower than for the control group. Nonetheless, the treatment group (the mainstream class) scored higher in definition questions and essay questions.

	Word	Definition	Essay	Effective communication mark
TG11	28%	74%	77%	87%
CG11	65%	36%	19%	7%

Figure 12. Performance in Grade 11 classes

5.3 After study period

The language awareness of treatment group students was assessed again using a sample answer script which contained the same language features at the word level, sentence level and text level concerning the procedure. The comparison of results is as follows.

Language feature		**Class**	**Mean**		
			Before	**After**	**Change**
Word level	Subject-specific vocabulary	TG10 Elite	4.36	4.05	-0.31
		TG11 Mainstream	4.00	4.20	+0.20
	General academic vocabulary	TG10 Elite	4.36	4.18	-0.18
		TG11 Mainstream	4.10	4.42	+0.32
	Signalling words	TG10 Elite	3.73	4.54	+0.81
		TG11 Mainstream	4.70	4.31	-0.39
Sentence level		TG10 Elite	3.60	3.93	+0.33
		TG11 Mainstream	4.20	4.00	-0.20
Text level		TG10 Elite	3.67	3.57	-0.10
		TG11 Mainstream	3.70	3.90	+0.20

Figure 13. Comparison of the language awareness of treatment group students

After the assessment, it can be concluded that the elite class students still had a keen awareness of subject-specific vocabulary and general academic vocabulary. Moreover, they had an increasing awareness of signalling words. At the sentence level, the elite class students had a better awareness of using imperatives. At the text level, the groups showed little difference.

Among the mainstream class students, they had a rising awareness of subject-specific vocabulary and general academic vocabulary and remained aware of short signalling words (e.g. then, next). However, they were relatively weak in long signalling words (e.g. at every thirty-second interval, at precisely the second minute).

After CLIL teaching and learning activities, the errors made by students in the pre-test were mostly eradicated. The following is a script from a Grade 10 student.

1. **Copper(II) sulphate forms a blue precipitate in excess alkali.**
   Name the alkali and write down a chemical equation involved.

   (2 marks)

   Sodium hydroxide

   [Teacher's comment: Correct concept]

   $CuSO_4 + 2NaOH \rightarrow Cu(OH)_2 + Na_2SO_4$

2. **What is 'a weak acid'?**

   (1 mark)

   A weak acid is an acid which partly ionizes in water.

   [Teacher's comment: Concrete and precise definition]

3. **Describe how to prepare calcium carbonate solids in the laboratory.**

   (5 marks*)

   Mix the calcium nitrate solution and sodium carbonate solution in a beaker.

   Then, filter off the precipitate from the reaction mixture.

   Next, wash the precipitate with a little cold distilled water.

   After that, transfer the precipitate onto a piece of filter paper with a spatula.

   Finally, dry the precipitate using filter paper.

   [Teacher's comment: Well-structured procedure with all points correct]

Comparing the data between the pre-study period and post-study period, in general, all data show positive results. The elite class students were more aware of signalling words and how to construct a sentence. Moreover, the mainstream class students were more aware of general vocabulary items. Over the course of the lessons, there was a remarkable growth in the abovementioned aspects.

5.3.1 Teacher Reflection

Multimodal activities used in lessons were not enough to build a context-rich lecture. Multimodal activities in Grade 10 lessons served as the start of a lesson, but there was no in-depth analysis using multimodalities. In Grade 11 lessons, there was an in-depth analysis of calorimeters – an instrument used for determining enthalpy changes. However, teacher-student interaction should be increased instead of showing the instrument alone.

Students acted responsively in underlining words highlighted by the teacher in chemistry lessons. However, they responded passively to detailed reading prompts. They actively attempted joint construction exercises; in fact, they tended to do the exercises on their own with little teacher intervention. It seemed that joint construction exercises were too easy for the students. They actively attempted independent construction exercises, and most of the students in both the mainstream and elite classes had high accuracy. Students actively attempted the parallel task, and most of the students in both the mainstream and elite classes showed high accuracy. Some students requested that more parallel tasks should be given in order to brush up their examination skills.

6. Discussion

6.1 Teachers' attitude to CLIL teaching

Science teachers not only welcome CLIL teaching strategies, but they knew how to employ some of the CLIL activities. For example, they knew how to do syllabification in order to break down words into several syllables not only for pronunciation but also for the meaning of prefixes, suffixes and word roots. While typical science teachers have mastered CLIL activities at the word level, teaching and learning activities for more complex language features, such as at the text and academic function levels, seem to be employed less frequently in lessons due to limited lesson time, which is similar to the situation reported by Poon et.al. (2013).

On the other hand, the teacher-researcher used CLIL teaching and tried to integrate the multimodalities-entextualization cycle (MEC) in lessons, with emphasis on the academic function and text levels. However, it seems that the use of multimodalities was not sufficient because there was not much time available in lessons to spend on multimodalities, compared with other parts in the MEC. Some students thought quite a lot of time was spent on language about how to construct a precise definition and write a structured essay, but not much time on the chemistry content, leading to less positive comments from students on the teaching package of MEC.

6.2 Students' attitudes to CLIL learning

As reflected in the questionnaire results, students generally made positive comments about the CLIL approach. They especially welcomed independent construction and parallel tasks, as these aspects resemble questions in examinations. When students know how to tackle questions in independent construction and the parallel task, they should be more confident of finishing questions of similar types in assessment tasks which helped increase their confidence in tackling questions in the examination.

However, there were still some limitations with this teaching pedagogy. Some students with high English ability reported that the package focused on language features, but it was not sufficient to promote their understanding of the chemistry content knowledge. It is because there was not enough time for developing a rich chemistry context. There may be some disconnections between concepts. Moreover, some students remarked that the joint construction part was not particularly useful as it was just a fill-in-the-blanks exercise, which was not practical for examinations. Therefore, modifications need to be made to enrich the content, using multimodalities and joint construction activities that go beyond fill-in-the-blank tasks.

6.3 Students' performance after CLIL learning

Progress in learning vocabulary in chemistry was one of the focuses in this study as many students expressed their concern about learning chemistry words. It was hoped that CLIL teaching would help to improve students' performance. However, contrary to expectations, the results were not promising. For Grade 11 mainstream class students, their results in the tests were similar. However, for Grade 10 elite class students, their performance decreased with time. That means they scored highest in the first test but lowest in the post-test since there are many variations concerning words in chemistry. When they learn a new topic, they need to learn new words. They cannot recycle what they have learnt in previous topics. Moreover, even if they know the words, they need to know how to apply them in suitable situations.

According to Johnstone (1997), students need to interpret knowledge in lessons in order to store chemical knowledge permanently. If students do not have sufficient time to interpret teaching and learning materials, learning effectiveness will not be high even with appropriate teaching and learning activities. Therefore, more emphasis should be placed on vocabulary items in future lessons. Moreover, from the results of the treatment group students, it seems that retention time is an essential factor in increasing the performance of students, as they need time to consolidate what they have learnt in lessons. The relationship between the effectiveness of learning chemistry at the word level and retention time should be further investigated.

Although there was little progress on increasing students' language awareness at the word level, their language awareness at the sentence level and text level did increase substantially. As revealed in the focus group interviews, no students mentioned difficulties in writing sentences or texts, indicating that students were not aware of the challenges at the sentence and text levels. However, inaccuracies in writing sentences and texts were found in their pre-test scripts, meaning that emphasis was needed to help students to refine their answers by paying attention to structural features. After CLIL teaching, the accuracy of the treatment group students increased when writing at the sentence and text levels because the variation of an academic function or a text structure is far less variable than vocabulary items. Students can grasp the principle of writing a particular sentence pattern or text easier than they can remember different words. On the other hand, the control group did not make much progress in improving their accuracy in writing sentences and texts, meaning that the CLIL teaching assisted students to increase their awareness of the sentence and text level.

It may be argued that the effectiveness of CLIL teaching in this study was questionable because elite students are mostly students with high ability. They should do well after receiving teaching and learning activities with an emphasis on essential points. However, if only elite students attain higher results than the mainstream class, a particular pedagogy might not benefit students with middle or low ability who need more assistance. The results in the Grade 11 treatment group, which was a mainstream class, also increased substantially.

The mean mark difference between the mainstream group and the elite group decreased. Moreover, the mean mark of the mainstream class was higher than that of the elite class. As a result, this teaching pedagogy was not only beneficial for the elite group but also for the mainstream group.

7. Conclusions and Implications

7.1 Students' content and language awareness

In connection with the first research focus, the extent to which students' content and language awareness was changed by increasing language support, their language awareness seemed to have increased after CLIL teaching and learning activities as they attempted more questions. Although more time was spent on using English for chemistry, students' content awareness was not sacrificed. On the contrary, students' growth in language awareness in turn made students more aware of subject knowledge as they read and wrote relevant words and sentences. When students produced accurate essays with the correct words and sentences, it led to an increase in performance in chemistry.

7.2 Students' and Teachers' acceptance of the CLIL approach

In connection with the second research focus, 'to what extent teachers and students accept the language-across-the-curriculum approach', students generally welcome this new teaching pedagogy, but slight modifications should be made to cater their ability and learning objectives. The teacher interviewee, a representative to typical Chemistry teachers, tend to use LAC activities in junior science but not for Chemistry. On the contrary, the teacher-researcher utilized the multimodalities and entextualization cycle (MEC), but further adjustments should be made in order to produce more content-embedded lessons.

7.3 Further modifications for the next run

Modification of the Teaching Package

Improvements are needed to improve the whole teaching package to enrich the context using multimodalities and joint construction activities. Experiments should be employed as one kind of multimodality at the start of the unit. This is because students expressed a strong wish to undertake more experiments, according to the questionnaire results. Experiments provide a rich context because they boost students' interest in chemistry. Furthermore, doing experiments is already a rich context. They involve much enquiry in different learning areas for students to solve problems embedded in experiments. In addition, students can learn from the laboratory manual so that they can learn how to transform instructions to procedures for their examinations. Using more activities should make students more able to benefit from content learning, as well as language learning. Therefore, an experimental enquiry approach should be one of the recommendations for teacher researchers.

In order to keep records for improvement, videotaping instead of audiotaping should be used. Fill-in-the-blanks problems should not be included in joint construction tasks. It is more beneficial for students to do an essay with guidance using verbal scaffolds. In order to finish these essay questions, teachers may give prompts to guide students to think about the words that are necessary for writing the essay. It is hoped that these modifications might better enable students to learn chemistry knowledge together with chemistry in English.

Although the parallel task was ranked the highest, many students would like to have more questions to brush up their writing skills. Therefore, in the next run, more questions resembling examination questions will be used as parallel tasks in order to increase the confidence of chemistry writing in essays.

The results for the word level question were not satisfactory. Retention time may be one of the factors here. However, more support should be provided to increase accuracy at the word level. The first modification will be to link up students' prior knowledge in order to spot word patterns.

More Emphasis on daily vocabulary and academic vocabulary

The second modification will be to compare and contrast the difference between daily vocabulary and academic vocabulary. For example, many students were confused about 'energy' and 'enthalpy' – they thought the words were the same. However, the real meaning of 'enthalpy' is 'energy per one mole of substance'. Such subtle differences should be emphasized in lesson time in order to increase accuracy in using subject-specific vocabulary.

As well as subject-specific words, signalling words are also needed for emphasis. Time adverbials are challenging for students, such as 'at exactly the 2nd minute'. Students misunderstood this to mean 'after 2 minutes'. However, 'at exactly the 2nd minute' refers to the point of time, but 'after 2 minutes' is a period. Such stress is essential in order to describe the time accurately.

7.4 Further investigations

The length of the study will be increased in the next run, which will mean that students should have enough time to understand the concepts. Their performance in word-level questions may change because of lengthening students' retention time. The relationship between the effectiveness of learning Chemistry at word level and retention time may be further investigated.

Many subject teachers nowadays are still reluctant to use CLIL teaching methods because of the long preparation time for developing lesson materials, which is not sustainable with a heavy teaching workload. Consequently, the sustainability of CLIL teaching as a method to bridge language support and self-directed learning may also be an issue.

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Abstract other than English (written in traditional Chinese)

科學類型寫作在科學評估中至關重要。本文旨在彙報一個鮮為人知的研究領域-內容與語言整合學習（CLIL）的科學課程如何促進英語作為外語（EFL）香港學生的科學知識發展。本文數據來自一項校本化學科的干預研究，研究方法包括調查問卷、評估和教師日誌中的書面數據，以及訪談和課堂觀察中的口頭數據。是次研究比較和評估了 CLIL 在各種教學活動的有效程度與其中背後意義。本文的結論是 CLIL 的教與學活動在英語能力較低的化學學習者中產生積極的學習成果。

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