CRITICAL THINKING IN THE CONTENT AND LANGUAGE INTEGRATED CLASSROOM: PERCEPTIONS OF SECONDARY MATHEMATICS TEACHERS IN OVERSEAS CANADIAN CURRICULUM CONTEXTS

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Abstract

This qualitative study explores the impacts of Content and Language Integrated Learning (CLIL) on students' mathematical critical thinking development in Canadian offshore secondary schools. Critical thinking is a necessary ability in modern society. Until now, the relationship between CLIL and mathematical critical thinking has not been fully examined, particularly in Canadian offshore schools. The objective of this study was to examine the impacts of CLIL in secondary mathematics in Canadian offshore schools for students from non-native English speaking backgrounds. The overarching research question for this study was: How do mathematics teachers working in schools using a hybrid Canadian and Chinese curriculum in China perceive the impacts of CLIL on the development of mathematical critical thinking in secondary students? Qualitative methods contributed to a study design that combined an email questionnaire and follow-up interviews to triangulate data for analysis. A constructivist theoretical framework supported the analysis of the data. Data indicated that CLIL could affect students' mathematical critical thinking development positively and negatively, as well as directly and indirectly. Three prominent themes, with a number of subthemes, were found throughout the data, including critical thinking, CLIL in mathematics classrooms, and critical thinking and CLIL. Participants referred to external and internal factors that could influence critical thinking development in CLIL and their beliefs related to CLIL. Those beliefs had major effects on pedagogical choices and, as a result, could influence the development of critical thinking skills. The results of this study can assist CLIL instructors in seeing what and how various factors affect students' critical thinking, thus creating better conditions for students to develop mathematical critical thinking. The findings point to future research related to gathering more perspectives and experiences of secondary mathematics teachers at other Canadian offshore schools.

Preface

This thesis is an original intellectual product of the author, Tian Li. The research reported in Chapters 3 to 5 was conducted through the protocols of The University of British Columbia's Okanagan Campus Behavioral Research Ethics Board (BREB) under the project title: Critical Thinking: H16-03003.

As per UBC's BREB guidelines, the data collection was conducted by Tian Li under the guidance of the Principal Investigator and the thesis committee. The committee for this project included:

- Dr. Scott Roy Douglas

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List of Abbreviations

BICS:	Basic Interpersonal Communication Skills
BREB:	Behavioral Research Ethics Board
CALP:	Cognitive Academic Language Proficiency
CLIL:	Content and Language Integrated Learning
CUP:	Common Underlying Proficiency
MS:	Microsoft
UBC:	University of British Columbia
UBCO:	University of British Columbia Okanagan Campus

Glossary of Key Terms

Language Acquisition:	The process of gaining or acquiring a language or language skills
Language Proficiency:	Being able to use linguistic skills and sociocultural competencies confidently as a skilled, valued, and knowledgeable community member.
Phenomenology:	The intentional reflective study of lived experiences

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Dedication

This thesis is dedicated to all educators who strive for better CLIL education.

Chapter 1

1.1 Overview of Chapter 1

Critical thinking is a necessary ability for all people in society. The complexities of contemporary life place great demands on the abilities and traits that are characteristics of comprehensive critical thinking (Aizikovitsh-Udi & Diana Cheng, 2015; Kurfiss, 1988). The public awareness of the importance of critical thinking increases with the growth of public awareness of the accelerating pace of change and complexity in modern lives (Willsen & Binker, 1993). A perceived lack of higher-order thinking ability among higher education students and the need for students to be able to think critically has resulted in a movement in which educators are being asked to promote critical thinking in the classroom (Idol & Jones, 2013). However, in some contexts, it may be that critical thinking is rarely encouraged and often actually discouraged for students who were educated in intellectual traditions such as China's (O'Sullivan & Guo, 2010). Chinese students who study abroad at the post-secondary level may lack critical thinking skills that will support their success in their programs of study (Tian & Low, 2009). As a result, the need to know how to best cultivate these students' critical thinking in secondary schools in China is becoming imperative.

As recognized by researchers such as Muthanna and Miao (2015), in the past few decades, English has come to be regarded as a global language. As the development of globalization and as more and more students choose to study abroad, especially in English speaking countries, the number of international secondary schools has been increasing dramatically in China. Many of these schools aim at preparing students for studying abroad by providing other countries' curricula. Adopting English as the medium of instruction has become more and more common in non-native English speaking countries (Muthama & Miao, 2015). More and more international secondary schools in China, such as Maple Leaf schools and Concord Colleges of Sino-Canada, that use a Canadian curriculum are trying to enhance students' English and academic knowledge through Content and Language Integrated Learning (CLIL). CLIL is defined as "… any dual-focused educational context in which an additional language, thus not usually the first language of the learners involved, is used as a medium in the teaching and learning of non-language content" (Marsh, 2002, p. 15 as quoted in Larsen-Freeman & Anderson, 2013). This understanding of CLIL is viewed as a method for both language learning and subject learning representative of these kinds of schools. For example, the Maple Leaf Educational Systems have a western academic orientation while maintaining Chinese traditions and culture, and they aim at preparing students to study in western universities. In 2016, Maple Leaf graduated 1422 grade 12 students, and more than half went on to study at a university rated in the top 100 internationally (Maple Leaf Educational Systems, 2016). In additional, as of 2017, there are 10 Concord Colleges of Sino-Canada in China with over 5,000 graduates. The first one, Beijing Concord College of Sino-Canada, has been established for 20 years (Beijing Concord College of Sino-Canada, 2017).

Additional language development is facilitated by social interactions (Vygotsky, 1978). Thus, it can be beneficial to English language learners to study within natural acquisition contexts since they provide more opportunities for students to be exposed to the language and interact with their social environment (Krashen, 1982; Long, 1996). Research has shown that using English as a medium of instruction can have a significant influence on students' learning where English is not the first language (Ebad, 2014; Launio, 2015; Li & Shum, 2007; Manh, 2012; Mufanechiya & Mufanechiya, 2010; Muthanna & Miao, 2015; Yip & Tsang, 2006).

However, the topic of students' critical thinking within the field of secondary mathematics in CLIL contexts has not yet been well explored. Therefore, this research study seeks to explore critical thinking in secondary mathematics classrooms in CLIL contexts.

This research project employed qualitative methods, including data collection tools such as an email questionnaire and online semi-structured interviews, in order to explore teacher perceptions of the impacts of CLIL on developing students' mathematical critical thinking in China. All participants were current or former teachers working at Canadian offshore schools. Based on the results gleaned from the participant data, it is proposed within this study that CLIL has both positive and negative influences on students' critical thinking development in mathematics classrooms and these influences are associated with many factors, such as schools' physical environments, resources, teaching methods, students' additional language proficiency, and teachers' beliefs.

1.2 Summary of Relevant Literature

Scholars have varying definitions of critical thinking. Dewey (1933) defined critical thinking as "active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends [to include] a conscious and voluntary effort to establish belief upon a firm basis of evidence and rationality" (p. 9). Glaser (1942) indicated critical thinking included three components: "an attitude of being disposed to consider in a thoughtful way the problems and subjects that come within the range of one's experiences; knowledge of the methods of logical inquiry and reasoning; some skill in applying those methods" (p. 5). Mcpeck (1981) described critical thinking as "skills and dispositions to appropriately use reflective skepticism" (p. 7). Lipman claimed that critical thinking was thinking which allowed judgment and relied on criteria, was self-correcting, and was sensitive to context (Lipman, 1991). Fisher (1995) suggested critical thinking was to explain what someone was thinking; learning to think critically was to learn how to ask, when to ask, what the question was, how to reason, when to use reasoning and what reasoning methods could be used. Chanche (as cited in Huitt, 1998), a cognitive psychologist, defined critical thinking as the ability to scrutinize facts, produce and organize ideas, justify opinions, make comparisons, draw conclusions, examine arguments, and solve problems.

One particularly influential definition was from Ennis (1985). For a general definition of critical thinking, this thesis project adopted Ennis' position on critical thinking as "reflective and reasonable thinking that is focused on deciding what to believe or do" (p. 45). In light of his definition, Ennis (1987) developed a critical thinking taxonomy that related to skills that include an intellectual aspect as well as a behavioral aspect. In addition to skills, Ennis's taxonomy included dispositions and abilities.

Ennis (1989) stated that there were three main approaches to promote students' critical thinking: infusion approach, the immersion approach, and the mixed approach. According to Swartz (1992), the infusion approach aimed at teaching specific critical thinking skills within different study subjects, and instilling critical thinking skills through teaching the set learning material. However, critical thinking was rarely encouraged and often actually discouraged for students who were educated in intellectual traditions in China (O'Sullivan & Guo, 2010).

Language, as a communicative tool, has a great effect on students' study and daily lives. Adopting English as the medium of instruction has become more and more common in non-native English speaking countries (Muthama & Miao, 2015). Increasingly, international secondary schools in China that use a Canadian curriculum are trying to enhance students' English and academic knowledge through CLIL, such as Maple leaf schools and Concord

Colleges of Sino-Canada. The use of English-medium instruction has become a strategy adopted by schools to prepare students to meet the demands of global markets. Additional language development is supported by social interaction theory (Long, 1996; Vygotsky, 1978). CLIL is a powerful way to support additional language acquisition through communication. The special character of content-based instruction is that it not only aims at language learning, but it integrates the learning of language with the learning of some other content (Larsen-Freeman & Anderson, 2013). In order to develop students' content learning and language learning simultaneously, teachers teach academic subjects while also teaching the language that is related to that content. Therefore, language becomes the medium for both English content and another subject content (Mohan, 1986). This approach cannot be viewed as being either language learning, or subject learning only, but an integration of both (Marsh, 2008).

Some research has shown that using English as a medium of instruction has a significant influence on non-native English speaking students' learning (Ebad, 2014; Launio, 2015; Li & Shum, 2007; Manh, 2012; Mufanechiya & Mufanechiya, 2010; Muthanna & Miao, 2015; Yip & Tsang, 2006). For example, Larsen-Freeman and Anderson (2013) stated that learning content and language together stimulated students' positive attitudes towards learning. Yip and Tsang (2006) claimed that students in English-medium instruction had higher self-confidence in mathematics in Hong Kong secondary schools. Launio (2015) indicated that success in mathematics was influenced by the medium of instruction and he believed that students taught in bilingual classrooms could gain better learning outcome than taught in pure additional language.

On the other hand, Manh (2012) pointed out that the use of English as the medium of instruction can leave the majority of children from diverse linguistic backgrounds marginalized and teachers confused, with students' participation levels being greatly reduced. Li & Shum

(2008) asserted that students without adequate English proficiency were greatly hindered in learning non-English subjects, became reluctant to ask questions and express ideas, and many even lost interest in the subjects and doubted whether using English in non-English subjects would help them learn English. Ebad (2014) pointed out that students and instructors who were non-native English speakers encountered high levels of challenges and obstacles during the course of classroom instruction in an English instructional environment.

1.3 Purpose of the Study

The purpose of this study was to explore the impacts of CLIL on the development of mathematical critical thinking in secondary mathematics for students from non-native English speaking backgrounds in China through looking into teachers' perceptions. Specifically, the current study explored how CLIL impacts learning because of students' additional language proficiency, and how CLIL in mathematics, in turn, supports students' additional language acquisition. The hope is that a clearer understanding of this issue may provide insight into more effective ways to support learners within a CLIL environment in different subject areas at the secondary school level, and promote mathematical critical thinking for these students, while also fostering a more inclusive educational environment in international high schools.

1.4 Research Question

The overarching research question for this study is as follows: How do mathematics teachers working in schools using a hybrid Chinese and Canadian curriculum in China perceive the impacts of CLIL on the development of mathematical critical thinking skills in secondary students? Related to the main research question, a number of sub-questions were developed to guide the research process:

1. According to the participants, what is mathematical critical thinking and what role does it play in mathematics classrooms?

2. How do the participants perceive CLIL and the relationship between CLIL and additional language acquisition in mathematic classrooms?

3. How do participants perceive the relationship between CLIL, academic content learning, and the development of critical thinking in mathematic classrooms?

1.5 Significance of the Study

While some research shows that CLIL has a significant influence on the learning process of students from non-native English speaking backgrounds (Ebad, 2014; Launio, 2015; Li & Shum, 2007; Manh, 2012; Mufanechiya & Mufanechiya, 2010; Muthanna & Miao, 2015; Yip & Tsang, 2006), little research has been done related to its impacts on the development of critical thinking and its relationship with additional language acquisition in secondary mathematics classrooms for students in China. This research is expected to fill the literature gap around the problems described in this research study.

Moreover, a study, which offers insight into how to develop and provide better educational practices to support students' needs and meet their social requirements, could be of significant interest for educational administrators and policy-makers. The gathered data in this research will help educators and educational policy-makers to gather valuable knowledge and ideas for designing better instruction and making better learning programs, which could then create more desirable and effective educational opportunities.

1.6 Overview of Research Methods

This study employed qualitative methods. The participants were teachers who had previously taught or were currently teaching secondary mathematics through CLIL in Canadian offshore schools. All participants had at least three years' teaching experience with either a teaching certificate in China or in Canada. The data was triangulated by using both an email questionnaire and a voluntary follow-up interview. The study was approved by the UBC Okanagan Behavioural Research Ethics Board (BREB) (Appendix E).

1.7 Limitations and Delimitations

Due to the fact that all participants involved in this study were from only a limited number of international secondary schools, the findings are not suitable for generalization. This was to be expected since the qualitative nature of this research had the goal of describing a particular context in a particular time, and not to generalize the findings to a wider population (Mills & Gay, 2016). It would be difficult to make any generalizations based on the findings due to the restrictions of collecting such a small sample (Lightbown & Spada, 2013). However, some collected data may be able to serve as an indicator for possible areas of interest of further study for other secondary schools. As this was a preliminary study with only a small number of participants, the data set was also limited. Moreover, the potential participants were known to the researcher as colleagues or friends, so they may have personal preferences or biases when doing the questionnaire or interviews. The researcher as well, through her knowledge of the participants, had to work at bracketing her own assumptions and biases as she was analyzing the data in order to remain objective (Creswell, 1998). However, through the information gathered from this research project, many valuable insights were generated in relation to critical thinking, mathematics teaching, and CLIL in Canadian offshore schools.

As some of the participants were teachers from non-English speaking backgrounds, there may have been language barriers that limited a full understanding of the researcher's intentions. The fact that these participants were coming from two different cultural and linguistic backgrounds may also have influenced the findings. Lightbown and Spada (2013) suggested that many individual differences, such as experiences, ethnic affiliation, age, and intrinsic and extrinsic motivation, were all factors that may influence people's perceptions. Therefore, these factors must be considered when analyzing these kind of data.

Finally, in order to interpret and report findings based on the data, many assumptions had to be made, including the fact that the participants were able to share an honest assessment of their experiences and perceptions about teaching in schools.

1.8 Definitions of Key Terms

One of the key terms used in the study was *critical thinking in mathematics* or *mathematical critical thinking*. Critical thinking has been defined by many scholars, as has been discussed in the summary of relevant literature. For the purposes of this research project that focused specifically on mathematical critical thinking, Glazer (2001) offered a useful definition. Glazer defined critical thinking in mathematics as "the ability and disposition to incorporate prior knowledge, mathematical reasoning, and cognitive strategies to generalize, prove, or evaluate unfamiliar mathematical situations in a reflective manner" (p. 13). This mathematically focused definition has been adopted for the current project. He explained that ability refers to a skill or power to demonstrate something and appeared to agree with Ennis (1987) that critical abilities used in critical thinking include finding support, making inferences, obtaining clarification, and using strategies.

CLIL uses content as a vehicle for additional language learning. This learning method puts the same emphasis on content learning and language learning (Marsh, 2008). Generally, when students study academic subjects not in their first language, they need a great amount of support to understand subject matter texts and to learn to use the academic language within the subject. Teachers must have both clear language learning objectives and content learning objectives in CLIL (Larsen-Freeman & Anderson, 2011).

1.9 Organization of the Thesis

Chapter 1 outlines the key elements and context of the thesis. Chapter 2 presents the literature related to the topic. Chapter 3 describes the qualitative research methods that have been used for this research. The findings and results obtained in the study can be found in Chapter 4. Lastly, Chapter 5 discusses the results and offers recommendations for further areas of practice and study.

Chapter 2 Literature review

2.1 Introduction of Literature Review:

This chapter focuses on reviewing national and international literature related to this study, the purpose being to provide a comprehensive summary of what has been written by others about the learning of mathematics in CLIL classrooms. The review offers a synthesis of what has been written on and around the topic of the study and what has not been written in terms of concepts and methodology, and how the researcher's study is going to address some of the gaps in the existing knowledge. It will summarize findings on the subject of CLIL in secondary mathematics classrooms. Research shows that using English as a medium of instruction has a significant influence on the learning of students from non-native English speaking backgrounds. This chapter looks what has been written in the scholarly literature as it relates to the current study.

The current study explores teachers' perceptions of the development of mathematical critical thinking in secondary mathematics in CLIL classrooms for students from non-native English speaking backgrounds in China. Students from non-native English speaking backgrounds refers to students who use English as an additional language rather than their mother tongue or their main language. The terms mother tongue or main language refers to the language that learners speak at home or most of the time.

English is used for communicative purposes and as a language of learning and teaching worldwide. English has spread all over the world as an international language (Moschkovich, 2005; Muke, 2005; Warschauer, 2000; Woolman, 2001). Using English as a medium of instruction has become prominent in school systems around the globe (Hornberger & Vaish, 2009; Mckay & Bokhorst-Heng, 2008). Some countries have adopted English to teach other subjects in order to promote both language and content learning—generally referred to as CLIL. This literature review discusses CLIL and critical thinking in secondary mathematics.

2.2 Sino-Canada Transnational Education

Sino-Canada refers to education that is a collaboration between China (Sino, from the Latin name for China, *Sinae*) and Canada. Transnational education is defined as education delivered by an institution to students located in another country (McBurnie & Ziguras, as cited in Zhang & Heydon, 2016). Since the 1990s, China's ambition to increase its global competitiveness in education has made progress into the field of transnational education (Huang, 2008). For the past several decades, countries such as the USA, UK, Australia, and Canada have been offering transnational education programs to China. For example, China has hosted a growing number of transnational education programs that adopt Canadian provincial educational curricula. As of 2015, Canadian elementary and secondary offshore programs have been offered in 20 provinces in China (Zhang &Heydon, 2016). In April 2015, there were 76 K-12 Canadian transnational education programs in China, about a 60% increase from November 2011 (The CICIC, as cited in Zhang & Heydon, 2016). Sino-Canada schools integrate subject area curricula that are transplanted from a certain Canadian province and are taught in English by Canadian certified teachers. Other subject areas are taught in Mandarin (Schuetze, Li & Sumin, 2008), or hybrid Canadian-Chinese subjects are taught in English by either Chinese teachers or Canadian teachers. Sino-Canada transnational schools are different from traditional public schools in the mainland of China which adopt only a Chinese curriculum and offer courses taught by Chinese teachers, except for English courses in some schools which may be taught by teachers from native-English speaking backgrounds. Since Chinese students in CLIL are not studying in their first language, their learning ability varies widely. In order to meet different students' demands, students with better English proficiency and mathematics foundation are chosen in some schools to learn mathematics using English as a medium of instruction taught by either Canadian teachers or Chinese teachers. One of those schools is Beijing Concord College of Sino-Canada, which is an example of Sino-Canada transnational education.

China has witnessed some new developments in bilingual education since the 1990s. Some local governments have encouraged, but not necessarily mandated, high schools, elementary schools, and kindergartens to implement bilingual education pilot programs that adopt English as the instructional language to teach academic subjects, such as mathematics and science (Xiao, 2016). However, acquiring a sufficient command of English to follow classes and succeed in tests is a great challenge for many students in using English as a medium of instruction (Schuetze, Lin & Sumin, 2008). There is some research on CLIL in many places, such as Italy, Mexico, Europe, Hong Kong, and so on. However, little research has been done around the topic in high school mathematics in mainland China, especially in Canadian offshore schools.

2.3 Mathematics Language

Language is a mediator of meaning (Vygotsky, 2002) that is fundamental and essential for learning mathematics (Moschkovich, 2002; Truxaw & Defranco, 2008). Botes (2010) stated that language and education were intertwined because all learning and teaching, such as discussions, group work, and presentations, are through the medium of language. Mathematical instructional language is important in learning and teaching mathematics because this subject is not only about computations, but also about competence, solving problems and mathematical communications (Adler, 2001; Botes, 2010; Cai, 2011; Ginsburg, 2008; Setati, 2003;Walt, et al., 2008). The language of mathematics creates a natural bridge between students' first language and the language of instruction in CLIL classrooms (Prochazkova, 2013). This bridge is because the concepts underlying mathematics are the same for both languages. The language of mathematics is the tool for mathematical thinking. For example, if teachers want to teach students how to solve the inequality x2-4>0, if students could understand the language of mathematics in the solving process in their first language, then it is much easier or not as difficult for them to understand the process in another instructional language; or if the students could not understand the instructional language, but they can understand the language of mathematics, then it can help to build a bridge for them to understand the instructional language in their first language. Petrova and Novotna (2007) used a figure like the one below (Figure 2.1) to describe the relationships among the language of mathematics, students' first language, and the instructional language.

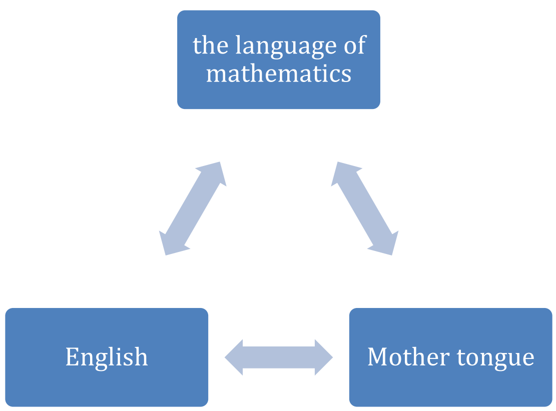

Figure 2.1 Relationships

Language register is used to refer to the meanings that have a special function in the language, and the words and structures that convey those meanings; a mathematics register, therefore, can be defined as the meanings belonging to the natural language used in mathematics (Cuevas, 1984). Mathematics language is sometimes different from conversational language, especially for mathematics registers. Mathematics is not about knowing and understanding

English, because mathematics language sometimes has different meanings than in daily spoken English language. According to Moschkovich, as cited in Nasir and Cob (2007), there are multiple meanings for the same term, and that mathematics learners need to use these different meanings appropriately in different situations. For example, the word prime can have different meanings when it is used to mean prime number, prime time or prime job. Multiple meanings in mathematics is confusing and challenging for students from non-native English speaking background in English as a medium of instruction (Nasir & Cob, 2007). Mathematics teachers have to teach mathematics and also English at the same time in CLIL classrooms, since learners are still learning English as an additional language.

2.4 Mathematical Critical Thinking

Different scholars have different definitions related to mathematical critical thinking. Ennis (1989) suggested that a mathematics-specific definition of critical thinking be generated since "mathematics has different criteria for good reasons from most other fields, because mathematics accepts only deductive proof, whereas most fields do not even seek it for the establishment of a final conclusion" (p. 8). Krulik and Rudnick (1999) indicated that critical thinking in mathematics was testing, questioning, connecting, and evaluating every aspect of a situation or a mathematical problem. Similarly, Sukmadinata (as cited in Palinussa, 2014) claimed that critical thinking was a skill of reasoning on a regular basis, systematic abilities in evaluating, solving problems, appealing decisions, giving confidence, analyzing assumptions, and scientific inquiry. Widyatiningtyas et al.(2015) stated that mathematics critical thinking was a kind of systematic ability to apply prior knowledge, mathematical reasoning capabilities and also be able to incorporate cognitive strategies into mathematical problem solving.

In consideration of all of the above definitions of critical thinking, which is not an exhaustive list, for the purposes of this research project that focuses specifically on mathematical critical thinking, Glazer's (2001) definition of critical thinking in mathematics has been adopted. In general, Glazer defined critical thinking in mathematics as the skill and tendency to use previous knowledge, reasoning abilities, and learning strategies to address unfamiliar mathematics problems. This mathematically focused definition has been adopted for the current project. Glazer explained that ability refers to a skill or power to demonstrate something and appeared to agree with Ennis (1987) that critical abilities used in critical thinking include finding support, making inferences, obtaining clarification, and using strategies. More specifically, Widyatiningtyas et al. (2015) provided several indicators of mathematics critical thinking skills:

1. Finding a relationship—students' ability to reconstruct the elements of the problem and formulate a relationship in the solution;
2. Analyzing data—students' ability to identify and take decisions on encountered problems;
3. Analyzing elements—students' ability to ascertain the elements contained in a relationship;
4. Analyzing the relationship—students' ability to check relationships and interactions between the elements of the problem and then make a decision.
5. Criticizing evidence—students' ability to make comments, add, detract, or rearrange a mathematical proof that they have learned.
6. Solving problems—students' ability in the examination results or answers in solving problems.

2.5 Education and language policies

Education and how it is implemented in different contexts is closely related to the unique linguistic characters of the places and participants who take part in the education processes. The inclusion of English in schools' curricula around the world has greatly increased over the last few years (Hu & Alsagoff, 2010). Seidlhofer (2011) claimed that English was "spreading in various and varied manifestations and adapted to the needs of intercultural communication" (p. 17) in different contexts. Governments from most countries are faced with the phenomenon that implementing English as a medium of instruction in schools is very important in relation to wanting to be immersed into and keep up with the rapid flow of information and communication with other countries around the world (Nunez Asomoza, 2015). Some work and research is now being processed not only bilingually, but also multilingually in different places around the world. Implementing English as a medium of instruction in schools seems to have proven to be successful to some extent in different places with different backgrounds. To support the development of bilingual and multilingual citizens, CLIL displays some potential for overcoming potential challenged related to English language teaching in some of the educational systems around the world (Nunez Asomoza, 2015). For example, CLIL can deliver a two for one benefit by teaching both language and content as the same time, thereby increasing the time available for language instruction (Larsen-Freeman & Anderson, 2011).

2.6 CLIL

Content and language integrated learning has become an important educational approach that has become an educational policy in the European Union related to language learning. Countries and institutions that have implemented additional language learning in their schools and curricula have worked with this innovative pedagogical approach that has become known in recent years as CLIL (Roiha, 2014). Coyle, Hood, and Marsh (2010) stated that CLIL "is a dual-focused educational approach in which an additional language is used for the learning and teaching of both content and language" (p. 1). Thus, it is important to emphasize that CLIL is neither language learning, nor subject learning but rather is an integration of both (Marsh, as cited in Larsen-Freeman & Anderson, 2011). CLIL is about using an additional language to learn, rather than just learning an additional language. The additional language becomes the medium for learning subject content, and courses have both content and language learning objectives. The goal is a two for one gain of both language and content (Larsen-Freeman & Anderson, 2011).

Unlike European countries that have developed and adopted clear linguistic policies for their education systems in relation to CLIL (Coleman, 2006; Dalton-Puffer, 2011; Lorenzo, 2007), Chinese authorities still do not have a policy to implement CLIL officially in public secondary schools. With China's growing globalization and economic integration into the world, the importance of English has strongly increased (Hu, 2008), and there have been accelerating societal and individual demands for English language proficiency in recent years (Hu, 2002). More and more private and international schools have emerged and adopted CLIL at the primary and secondary levels of education in China in the past decade (Wang, 2003), and they have drawn considerable public attention. There is still a long way to go before Chinese teachers and the Chinese educational system in general are able to accomplish what has been accomplished so far elsewhere, especially in European countries, in implementing CLIL.

2.7 CLIL and Critical Thinking

Cognitive skills are at the very core of critical thinking (Facione, 2004). CLIL provides a desirable learning environment where learners can get a chance to use their cognitive skills and to construct their own knowledge (Hanesova, 2014). They are intellectually challenged to transform information, to solve problems, and to discover meanings. For meaning-making, Hanesova (2014) claimed that learners used these thinking skills especially: “analyzing, differentiating, organizing, classifying, comparing, matching, synthesizing, guessing, evaluating, and creating” (p. 1) and through this process learners developed flexibility in their thinking.

Moreover, there are some cognitive benefits like cognitive flexibility, better problem solving abilities, and higher order thinking skills when adopting an additional language to learn mathematics in classrooms (Truxaw, 2014; Zahner & Moschkovich, 2011). Higher thinking skills are stimulated in the instruction of additional languages or in the change of language of instruction since language spontaneously employs learning activities associated with analysis, synthesis, and evaluation (Prochazkova, 2013).

In addition, research has shown that students’ ability to think critically is related to many things, including learning experience, the growth of self-control and self-awareness, linguistic and reading abilities, and subject knowledge (De Boo, 1999). CLIL may affect the development of students’ mathematical critical thinking through influencing their learning experience, changing the language of instruction, and impacting their academic learning.

2.8 Second (Additional) Language Acquisition

A variety of second, also known as additional, language acquisition theories support an analysis of how and why students gain an additional language in CLIL environments and the role of CLIL in additional language learning. The understanding of these theories is important since it gives insight and background as to what may be the most important factors in additional language learning and how to create the most conducive and effective environments for additional language learning to occur in a CLIL mathematics classroom. Several concepts related to additional language acquisition theories are discussed in the following section: comprehensible input, the affective filter, interaction, and motivation.

Comprehensible input is necessary for language acquisition (Krashen, 1982). Acquisition occurs when one is exposed to language that is comprehensible and contains *i*+1 (Krashen, 1982). The '*i*' represents the level of language in the present moment and '1' represents language that is just a step beyond the current level (Lightbown & Spada, 2013). In other words, people acquire an additional language when they understand messages they see (read) and hear, with only a slight amount of challenge.

The affective filter is used by Krashen (1982) to describe how students need to proceed in a calm emotional state to learn. The affective filter can act as a metaphorical barrier to prevent learners from acquiring language even when they are exposed to large quantities of comprehensible input. Comprehensible input cannot be understood when an individual is experiencing high levels of negative emotions. As a result, affect refers to feelings of anxiety, stress, or negative attitudes that may be associated with poor learning outcomes. If the affective filter is high, the input could be filtered out and learners may not acquire language successfully.

Long's (1996) interaction hypothesis has described the way that language learners improve their additional language through interacting with sympathetic interlocutors. Long felt that learners have to have the chance to interact with other users, and only experiencing input is not enough. Moreover, during interaction, learners and interlocutors have to cooperate with each other to reach mutual understanding or make the input comprehensible for the less proficient speaker. Long claimed that modified interaction was necessary to make language comprehensible. Modified input occurs when proficient language speakers change or adapt their speech and language to communicate with less proficient speakers. Additional language learners benefit from the efforts of highly proficient speakers and fluent bilinguals who modify their speech to help them understand.

Motivation can refer to the drive for learners to acquire an additional language. Lightbown & Spada (2013) have outlined what motivation is in additional language acquisition and how it can be achieved for a good language learner:

> Motivation in second language learning is a complex phenomenon. It has been defined in terms of two factors: on the one hand, learners' communicative needs, and on the other, their attitudes towards the second language community. If learners need to speak the second language in a wide range of social situations or to fulfill professional ambitions, they will perceive the communicative value of the second language and are therefore likely to be motivated to acquire proficiency in it. Similarly, if learners have favorable attitudes towards the speakers of the language, they will desire more contact with them. (p. 87)

Further, Gardner & Lambert (1972) used two terms to describe motivation. First, they defined instrumental motivation, which meant learning a language for a quick or immediate need. Second, they defined integrative motivation, which was for personal growth and cultural enrichment. Both types of motivation can be used separately or together in the learning process. Different learners can be motivated by different factors.

In reviewing the literature on comprehensible input, the affective filter, the interaction hypothesis, and motivation, these concepts can work together to create a theoretical understanding of additional language acquisition for teachers to create the most effective environments for students in CLIL mathematics classrooms as they acquired English as an additional language.

2.9 Additional Language Acquisition and Mathematical Critical Thinking

Some research has shown that students' additional language learning may affect their critical thinking development. Additional language acquisition may affect students' learning attitudes toward mathematics and, as a result, their self-efficacy; Self-efficacy may impact students' mathematical critical thinking development since it is related to effort, persistence, and resilience (Truxaw, 2014). According to Chamot and O'Malley (1994), in CLIL, because of the integration of academic content and language, the development of critical thinking skills seems to be connected to the development of language functions. They illustrated that the content activities that need critical and creative thinking skills also required more complex language and richer vocabulary to be used. Moreover, Fahim (2014) claimed that there was a significantly negative relationship between students' development of critical thinking skills and their anxiety in additional language learning. He indicated that students with more anxiety in additional language learning tended to have lower development of critical thinking. Students' learning of an additional language may affect their development of critical thinking. Therefore, it is necessary to look at the relationship between students' additional language acquisition and their development of mathematical critical thinking in CLIL classrooms.

2.10 Impacts

Much research shows that adopting English as a medium of instruction has a huge influence on students' learning with non-native English speaking backgrounds. On the one hand, positive influences have been reported in the research. For example, Larsen-Freeman and Anderson (2013) assumed that learning content and language together could keep students interested and motivated. Yip and Tsang (2007) claimed students had higher self-confidence in mathematics in English instructional environments in Hong Kong secondary schools and students' self-confidence in mathematics had a positive relationship with their academic performance. Thus, it seems that CLIL can boost student confidence in mathematics class with positive effects on their studies. Moreover, Launio (2015) indicated that success in mathematics was influenced by the medium of instruction, and he believed that students taught in bilingual classrooms (native language and additional language) could learn better than in pure additional language settings. It appears that students learning only in English may have trouble understanding the monolingual instruction. However, when students' first language is used to supplement CLIL, it can enhance students' understanding of content. On the other hand, adopting English as a medium of instruction may have some drawbacks as well. Manh (2012) pointed out that the use of English as the medium of instruction in Vietnam in a range of subjects had left the majority of the students marginalized and teachers confused while students' participation levels were greatly reduced. Li & Shum (2008) asserted that students without adequate English proficiency were greatly hindered in learning non-English subjects, became reluctant to ask questions and express ideas, and many even lost interest in the subjects and doubted whether using English in non-English subjects would help them learn English. Furthermore, Ebad (2014) pointed out that students and instructors who were non-native English speakers encountered high levels of challenges and obstacles during the course of classroom instruction in an English instructional environment.

2.11 Challenges

There are compound challenges when using an additional language while trying to learn mathematics (Alanis & Rodriguez, 2008; Cummins, 2000, 2005; Hu, 2007; Moschkovich, 2002, 2007, 2013; Rojas, 2005; Truxaw, 2014), and CLIL should be used carefully in order to develop students' critical thinking skills. One of the many challenges around the world is that there is a serious shortage of teachers with competent levels of English language proficiency for engaging in English medium instruction in mathematics in most countries where English is not the first language (Luo and Liu, 2006; Shen 2004; Zhang & Liu, 2005; Zhu 2003). This constraint is so critical that Luo and Liu (2006) regarded it as a bottleneck of English medium instruction in the mainland of China. Because the Chinese teacher education system did not have a bilingual teacher educational program until recent years, teachers have been educated to be either subject teachers in Chinese or teachers of English as an additional language (Zhang, 2002). Teachers do not have the oral or academic language competence to teach non-language subjects bilingually (Pi, 2004), a challenge which continues to this day. Thuzini (2011) claims that non-English-speaking mathematics teachers face challenges and difficulty in mathematics using CLIL. They cannot judge the reasons learners do not respond to questions or fail tests since it could be students did not gain the academic knowledge or because of their limited English language proficiency. In addition, students may have more difficulty in understanding the English because of teachers' pronunciation and lack of fluency in the language.

Another challenge is students' lack of a threshold proficiency in English to benefit from English medium instruction (Hu, 2007; Ye 2002). In some cases where learners use English as an additional language, they seem to be passive in their learning and are not active participants in their learning, compared to when using their mother tongue (Botes and Mji, 2010). Yeh's (2014) research also showed that the medium of instruction might, to some extent, influence students' class participation. Teachers cannot predict whether the problem is with English or with the solving of mathematics problems (Botes & Mji, 2010). Students' limited proficiency in English results in learning difficulties in many ways, including but not limited to the misunderstanding of questions and teachers, passive participation in group discussions, and inability to read information (Botes & Mji, 2010). Jusoff (2009) and Ong (2006), as cited in Thuzini (2011), listed some of the factors that contribute to the inability of learners to be involved effectively in mathematics using English as an additional language. These factors include teachers who are not proficient in English; students' backgrounds; poor relationships between teachers and learners; students' feeling towards mathematics as a subject, and so on. Pretorius (2000) has affirmed the need for proficiency in the language in order for learners being taught in English to improve their academic performance. Sometimes learners who are taught in an additional language do not achieve academic excellence, not because they are struggling with content but because of language barriers (Adler, 2001; Botes, & Mji, 2010; Nasir, 2007; Setati, 2008). In addition, students are more prone to use their first language in learning mathematics and believe that the teaching and learning of mathematics will be more effective if conducted in their mother tongue directly (Ahmad et al., 2012).

2.12 Teachers' Attitudes

Students' English language proficiency is the most important factor that teachers need to consider when employing CLIL. Mathematics teachers have complained that students could hardly understand English as a medium of instruction in mathematics lessons (Launio, 2015). Moreover, teachers have said that lessons in CLIL took up too much time and CLIL made lessons a little bit slower since they needed to use strategies and tools to better employ CLIL as a teaching method, and students needed more time to grasp subject area content (Tan, 2011). In addition, teachers tended to put more emphasis and priorities on content learning than language learning while adopting CLIL, which deviates from the professed goals of CLIL in having both language learning and content learning outcomes. Mathematics teachers typically have been identified as being very concerned with subject matter mastery and student achievement since they work within an exam-oriented education system (Tan, 2011).

2.13 Students' Attitudes

Much research has shown that CLIL could have some effects on students' learning attitudes. Within the Chinese context, Muthanna and Miao (2015) reported that students at the university level learning in English medium classrooms have positive attitudes towards CLIL. Hoffmannova (as cited in Prochazkova, 2013) further suggested that by employing diverse approaches, CLIL provided a desirable environment that could address the needs of students with various learning preferences. Working within the context of students studying English-medium mathematics in the Czech Republic, Prochazkoza (2013) also claimed that CLIL could change the attitudes of many students towards mathematics in a positive way. Tejkalova (2009) also has confirmed that CLIL has generally been regarded as motivating and challenging by the learners in mathematics. Nixon (as cited in Prochazkova, 2013) claimed that teaching subjects through an additional language could build students' confidence and extend their knowledge, engage their curiosity, and increase motivation.

CLIL helps to develop students' positive attitudes towards language learning (Bebenroth & Redfield 2004; Lasagabaster & Sierra, 2009) and enhances learners' motivation in both language and non-language subject (Wiesemes, 2009). However, besides additional language acquisition, Huang's (2009) research has shown that students were worried about the potential loss of academic subject knowledge, i.e. content, resulting from a slower speed of course delivery while they had an increased confidence or interest in English learning in CLIL. Students may encounter no obvious difficulty in understanding the English language of lectures. However, they may have had only a superficial grasp of academic content and therefore be uncertain about their acquisition of subject specific content knowledge (Yeh, 2014).

2.14 Theoretical Framework

As Bonk and Cunningham (1998) stated, instructional strategies and tools must be based on a theory of learning. This study is informed by a constructivist understanding of learning. Powell and Kalina (2009), as cited in Thuzini (2011), divided constructivist theory into two kinds: cognitive or individual constructivism and social constructivism. Cognitive constructivism is based on Piaget's theories, and social constructivism is influenced by Vygotsky's theories (Thuzini, 2011). Cognitive constructivism suggests that ideas are constructed in individuals through one's mind. However, social constructivism suggests that ideas are constructed in collaboration with others. For Vygotsky (1978), learning takes place in the metaphorical space created between what one can do on one's own, and what one can do in collaboration with more capable peers. Phillips (1995) stated that constructivists like Piaget and Vygotsky have been concerned with how the individual learner creates knowledge. Constructivist theory helps with the idea of being learner-centered in the learning and teaching process, where learners use their prior knowledge to solve problems individually or as a group, and not just through the simple transferring of knowledge from the teacher's mind to the learner's mind. Bonk and Cunningham (1998) explained that fundamental issues in teaching and learning could be described through key words as "constructivism" and "learner-centered" and the idea behind those key words was that learners could learn best when they were involved in the topic and motivated to seek out new knowledge and skills because they needed them in order to solve the problem at hand.

CLIL should be considered as a constructivist approach to learning (Dalma, 2003). One core feature of CLIL is that learners construct their own learning using their cognitive skills.

They are intellectually challenged to transform information, to solve problems, and to discover meaning. In this process, learners use their critical thinking skills (Hanesova, 2014). This kind of learning can contribute to their critical thinking in mathematics. Moreover, as a teaching method grounded within a constructivist theoretical framework, CLIL provides a new type of learning focused on the integration of various aspects of learning. It uses an additional language as a medium for meaningful communication of specific content under natural conditions (Hanesova, 2014). It has the real potential to promote learning because it refers to authentic situations of acquiring knowledge from various subjects via an additional language (Gondova, as cited in Hanesova, 2014). Students do not only learn an additional language for the sake of language learning, but they also learn the language to find out new information in the target language and to think in that language while learning subject content, such as mathematics (Marsh, 2002). In addition, the emphasis is moved from the teacher to the learner.

Thus, constructivist theories of education guide an understanding of whether CLIL in secondary mathematics in China fits within its framework. In other words, when using CLIL in secondary mathematics, the researcher was seeking to find out if teachers could give students the opportunity to construct their own understanding from their prior knowledge, if students could take advantage of the opportunity to use their cognitive skills and to construct their own knowledge, and if teachers could use CLIL properly to develop students' mathematic critical thinking skills under their specially designed educational conditions. For this study, the perceptions of teachers teaching in China using a CLIL approach (teaching in English) for teaching secondary mathematics is the main focus being explored by the researcher.

Chapter 3 Research Methodology

3.1 Introduction to Chapter 3

The focus of this chapter is on the methods used to create and conduct this research study. First, a rationale for the research study is provided, followed by the philosophical perspectives. The chapter further elaborates the research study via the research design, the research questions and hypothesis, a description of participants, research instruments, data collection procedures, data collection and statistical analysis, validity, trustworthiness, and reliability. A summary is provided at the end of the chapter to condense the main points of this chapter.

3.2 Rationale for the Study

Critical thinking is a necessary ability for all people in society. The complexities of contemporary life place great demands on the abilities and traits that are characteristics of comprehensive critical thinking (Aizikovitsh-Udi & Diana Cheng, 2015). However, there is the possibility that Chinese students who study abroad at the post-secondary level may lack critical thinking skills that will support their success in their programs of study (Tian & Low, 2011).

English has come to be regarded as a global language in the past few decades and adopting English as the medium of instruction has become more and more common in non-native English speaking countries (Muthama & Miao, 2015). CLIL, defined as "… any dual-focused educational context in which an additional language, thus not usually the first language of the learners involved, is used as a medium in the teaching and learning of non-language content" (Marsh, 2002, p. 15), was used throughout this research study as a universal term to identify the phenomenon of adopting English as a medium of instruction in mathematics.

In this research study, it has been hypothesized that the development of critical thinking is related to students' learning process and teachers' instruction. The research study conducted here explored teachers' perceptions of the impact of content and language integrated learning on students' development of mathematics critical thinking. The information that was gathered has the possibility of being used to guide future development of CLIL programs and assist secondary education stakeholders (teachers, students, administrations, etc.) in further comprehending CLIL's influence on students learning, teacher instruction, and how educators may perform better in CLIL environments focused on mathematics and critical thinking.

3.3 Research Questions

The overarching research question in this study was concerned with how secondary mathematical teachers perceive CLIL's effects on students' mathematical critical thinking development in secondary schools based on their own teaching experience. Thus, the overarching question for this study is as follows:

> How do mathematical teachers working in schools using a hybrid Canadian and Chinese curriculum in China perceive the impacts of CLIL on the development of mathematical critical thinking in secondary students?

Sub questions have been developed in order to better explore the overarching question:

1. According to the participants, what is mathematical critical thinking and what role does it play in mathematics classrooms?
2. How do the participants perceive the relationship between CLIL and additional language acquisition in mathematics classrooms?
3. How do participants perceive the relationship between CLIL, academic content learning, and the development of critical thinking in mathematics classrooms?

3.4 Research and Philosophical Perspective

This was a qualitative study that connected CLIL and mathematical critical thinking at the secondary level in Canadian offshore schools. The purpose of this research study was to explore the impact of CLIL on students' mathematical critical thinking development by exploring teachers' perceptions based on their teaching experiences. Gay, Mills and Airasian (2012) defined qualitative research as "the collection, analysis and interpretation of comprehensive narrative and visual data to gain insights into a particular phenomenon of interest" (p. 7). Moreover, qualitative practices indicate the researchers accept the notion that some research is unpredictable, specifically when working with individuals. Since this research was centered on CLIL and students' development of mathematical critical thinking and the participants were teachers from Canadian offshore schools, qualitative research was the best choice for this study, over other research methods, as it conformed to the participant's needs. It was also the best choice because through sharing stories and insights related to employing CLIL in mathematics classrooms, the participants' perceptions could provide a rich description of the development of critical thinking as it relates to the teaching and learning of mathematics in offshore schools. Participants were answering questions as individuals, expressing their own past and present experiences and opinions within the CLIL programs. Moreover, participants could interpret questions to have different meanings based on their teaching experience in CLIL and personal background, and they may have different answers to the same question. However, all of their opinions were of equal value. In addition, a qualitative research method provided the fluidity and freedom needed for proper participation expression in this study.

An important point in a research study is to decide the philosophical stance. The current study employs qualitative research methods influenced by the phenomenological tradition.

Phenomenology is “a qualitative approach in which the researcher focuses on capturing the experience of an activity or concept from participants’ perspectives” (Gay, Mills, & Airasian, 2012, p. 629). According to Creswell (2007), a phenomenological study describes “the meanings of several individuals of their lived experiences of a concept or a phenomenon” (p.57), including what and how they experience the concept or phenomenon. As this study involved exploring what different experiences mean for the participants in order to gain a deeper understanding of a particular issue or “phenomenon”, in this case the development of mathematics critical thinking skills through CLIL, phenomenology resonates well with it.

Thus, an approach influenced by phenomenological tradition informs the choice of study participants, the collection of the data, and its analysis throughout the study. One of the objectives of the study was to comprehend mathematical teachers’ experiences in order to explore their perceptions about CLIL in secondary mathematics in Canadian offshore schools. By doing so, a better understanding can be grasped of how CLIL influences students’ mathematical critical thinking, taking into account both positive and negative aspects.

The researcher insisted on obtaining and interpreting data in a process as unbiased as possible in order to keep objective, a process called bracketing (Creswell, 1998). As Groenewald (2004) claims, the goal of phenomenology is to keep away from any pre-given framework and remain true to the facts. The key goal for this study was to keep pre-existing viewpoints from the collection process and provide opportunities for participants to share their perspectives.

3.5 Research Design

The research design for this study involved the purposive sampling of participants and the creation of an email questionnaire consisting of both close and open- ended questions. This questionnaire was confidential and was preceded by participant recruitment consisting of an invitation letter and consent form. The questionnaire was followed by a semi-structured interview. Once the data were collected, qualitative methods were used to code key units of meaning in the data and gather those codes together into emerging themes related to the research questions (Gay, Mills, & Airasian, 2012).

This research study was low risk and any identifying information such as e-mail addresses for questionnaires and interviews, was kept completely confidential. The data were secured and stored safely on Canadian servers when used online. All of the information used for this study was kept completely confidential. There was no hard copy of data and all electronic data will be stored in a locked cabinet for five years and then destroyed via formatting or other means. Additionally, the data for the questionnaires were stored in UBC email system first. Anything electronic was removed from the computers of the investigator (participants' personal information, emails, etc.) at the completion of the study and all other electronic information is stored in a safe location on a hard drive. Again, the electronic information will be stored for five years and then erased off of the hard drive appropriately at the end of the said five years' period.

3.6 Participants and Research Setting

3.6.1 Participants

Purposive sampling was used to recruit participants. The researcher identified criteria to select participants, and used her knowledge and experience of offshore schools to identify potential participants who would be the most informative (Gay, Mills, & Airasian, 2012). The potential participants (teachers) were chosen potentially from a number of different schools and may have had either English or non-English speaking backgrounds. Potential participants were mathematic teachers with at least three years' teaching experience and were known to the researcher. These participants were chosen because they could provide the researcher with the most informative data and insights related to CLIL classrooms and mathematics teaching in Canadian offshore schools. An email invitation letter with questionnaire, interview questions, and consent form was sent to eight potential participants. Once potential participants had read through the invitation letter and the information on informed consent and agreed to take part in the study, they could download and open the questionnaire sent by email (automatically indicating that they were consenting to the questionnaire portion of the study). All of the participants in this study were secondary mathematics teachers in China who had adopted CLIL in their classrooms. In the end, there were seven participants who took part in the email questionnaire of the study, seven who participated in the online semi-structured interviews. Of those participants who took part in the interviews, three participants completed the interview in two sessions. Table 3.1 provides demographic information related to all participants. The participants were between the ages of 27-54 years of age and had teaching experience in Canadian offshore schools. All participants had at least three years' teaching experience in CLIL in Canadian offshore schools.

Table 3.1

Demographic information of participants

Name	Age	Gender	First language	Relevant Teaching experience	Grade
Yi	54	Male	Chinese	11	G10, G11, G12
Ma	38	Male	Chinese	7	G11, G12
Li	33	Female	Chinese	6	G10, G11, G12
Liu	49	Female	Chinese	11	G10, G11, G12
Mei	30	Female	Chinese	7	G10, G11, G12
Wang	27	Male	English	3	G10, G11, G12
Sara	28	Female	Chinese	5	G10, G11

3.6.2 Research Instruments: Email questionnaire and Interview Questions

The research instruments used for this research study were employed in two phases: first an email questionnaire for potential participants and second a semi-structured online interview. Some participants had interviews with two sessions so that they had time between to think and provide more examples. All participants were offered this option, and the second session was referred to as a follow-up interview.

Both phases of the study (questionnaire and interviews) were approved by the UBC Okanagan institutional research ethics board (Appendix E) and were reviewed by the researcher and her supervisor. The vocabulary and word content were carefully reviewed by the researcher to ensure the level of comprehension was at or below that of a Chinese College English Test 6 level. This level of comprehension was acceptable because, although some participants were originally from non-English speaking backgrounds, they had attended university and passed the Chinese College English Test 6 level in order to be employed by Canadian offshore schools to teach mathematics through CLIL. Thus, it was a fair assumption to make that they could read and comprehend English at Chinese College English Test 6 level.

In the email questionnaire (See Appendix C), participants answered questions about their personal background, provided opinions based on their teaching experience, and related their teaching experience in CLIL mathematics classrooms. At the end of the questionnaire, the participants could volunteer to take part in the follow-up semi-structured interview and provide information to be contacted at a future date to do the interview. After that, they sent completed questionnaires back to the researcher by email.

In the follow-up interview, there were open-ended questions asked and recorded (See Appendix D). Many questions used in the interview were designed in advance by the researcher. During the interview, the researcher probed deeper with impromptu open-ended questions if needed. Some participants had interviews over two sessions so that they could have time between to think about the questions. At the end of the first session, participants were asked if they needed time and wanted to provide more elaborated examples in a second interview session (a continuation of the first interview, not a new interview), which was based on the information they provided in the first session.

3.6.2.1 Email Questionnaire Questions

The email questionnaire was created by the investigator using MS Word and sent via email to potential participants. The same questionnaire was used for each participant. A copy of the email questionnaire is included in Appendix C. Initially the researcher wrote an invitation letter including the introduction of the study, the research instruments, and an explanation of the informed consent attached to the email.

By downloading and completing the questionnaire file attached by the researcher, participants offered their consent to take part in the questionnaire; hence, a separate consent form for the questionnaire was not required. The questionnaire included six demographic questions on educational degree, age, gender, first language identification, teaching grades, and length of teaching experience thus far adopting CLIL. The second section of the questionnaire was "short answer questions" and included eight questions developed around critical thinking and CLIL. A copy of the questionnaire can be found in Appendix C. Lastly, the participants were invited to provide their email addresses if they would like to be contacted further for volunteer participation in the follow-up interview portion of the study.

3.6.2.2 Interview Questions

The semi-structured open-ended interview after the questionnaire was voluntary. On the questionnaire, there was a question asking participants if they wanted to take part in a further semi-structured interview. If participants indicated on the questionnaire that they were willing to take part in an interview, they were contacted by the researcher. At the time of the semi-structured interview, participants were orally reminded of informed consent, and provided with an opportunity to withdraw from the study. The same basic questions were used during the semi-structured interviews for each participant. After participants finished the first semi-structured interview session, they were asked if they needed more time and were willing to provide more elaborated examples in a further session. The interview questions were created specifically to elicit the opinions, thoughts, perspectives, and experiences in further detail as related to CLIL and critical thinking. The semi-structured interview questions are included in Appendix D.

3.7 Data collection Procedures

3.7.1 Recruitment for the Study: Email Questionnaire

There were seven participants who completed the email questionnaire. The researcher obtained a sample of convenience from teachers who were known to the researcher and had at least three years' teaching experience in Canadian offshore schools.

Qualitative non-random purposive sampling techniques were used because the researcher was seeking to describe teacher perceptions of critical thinking in CLIL mathematics classrooms in depth, and these potential participants could best contribute to understanding the phenomenon in question (Mills & Gay, 2016). It was made clear that the research conducted was confidential and voluntary; additionally, this study would not affect participants' work status and life within schools. The researcher sent an invitation letter, a consent form, and a questionnaire to participants by email.

The questionnaire was sent by email to participants instead of in person because it was convenient for both the investigator and the participants. At the start of the email questionnaire, participants were reminded to read the information about informed consent, and had time to think about their participation and ask questions via email if they were unclear about any aspects of the research. The researcher's contact information was available in the informed consent information. The participants had 15 days to decide if they wished to participate or not. Participants could provide informed consent to participate in the project by completing the online questionnaire, and indicating "yes" in the first question. Participants had the option to drop out of the study at any time by not submitting the questionnaire or informing the researchers.

3.7.2 Recruitment for the Study: Interviews

Of the seven participants who completed the email questionnaire, seven participants also took part in the semi-structured interviews (note: three of them completed their interviews over two sessions). The participants who took part in the semi-structured interview had been asked at the end of the questionnaire if they would like to participate a follow-up interview; the participants who participated in two interview sessions had been asked at the end of their first interview session if they needed time and were willing to do a further interview session. Again, these interviews were completely voluntary and optional, and they would not affect their work status and life within their schools.

3.7.3 Data Collection: Email Questionnaire

Participants were asked to send the completed questionnaires to the researcher through email. Any identifying information was kept confidential, and identifying information was kept separate from the data. Pseudonyms were chosen for the participants during the study to protect their confidentiality.

The close ended demographic questions categorized participants into groups according to gender, first language, length of teaching, and other factors of interest to help inform the subsequent analysis. The open-ended questions about experiences were reviewed and analyzed to find themes and patterns in the qualitative data. The data were coded into specific themes and then categorized by most common to uncommon, thus giving a priority order of the specific themes expressed by the participants (Mills & Gay, 2016).

3.7.4 Data Collection: Interview

All seven participants who completed the questionnaire also took part in the interview stage of this research; thus, seven transcriptions were completed. The participants who indicated on the questionnaire they were willing to take part in an interview were emailed by the investigator about the follow up interviews and at the end, all seven of them positively replied and took part in the semi-structured interviews. Appointments were made with each participant to meet online with both participant and researcher in a private space to keep the study confidential. Each appointment lasted one to two hours: 10 minutes for the introduction and consenting process and the rest for the interview.

Before the interview started, the investigator gave a brief introduction to the interview and discussed the interview consent form with the participants. They then were required to say yes to agree and continue participating in the interview. Because of the semi-structured nature of the interviews, some questions were also developed during the process of the interviews to probe further information.

Seven participants were interviewed, the information was audio recorded and then transcribed into Microsoft Word in a script format. The investigator checked over this information to be sure all of the correct sounds and wording were transcribed. Once the transcripts were completed, they were shared with participants for them to have the opportunity to review the transcripts and provide feedback on accuracy of the information transcribed. To keep the participant's identity confidential, pseudonyms were used during the transcriptions. At this point the data analysis began. The investigator read through the transcription, developing emerging themes and patterns by coding through the qualitative process.

3.8 Data Analysis

Data analysis began after data were collected by email questionnaire and semi-structured interviews. The impacts of CLIL and how its influences work were the focus of these data collecting instruments since these elements related to the research question. Once the data were gathered, all of coding was completed manually in MS Word, using available commenting tools, and coding software was not used.

Data collected from the first part in the email questionnaire were used for collecting demographic information from participants. Data collected from the second and third parts in the email questionnaire were analyzed in conjunction with the interview data as similar questions were asked on both research instruments. Questions in the second and third parts of the email questionnaire played an important role in helping the participants think about the topic and preparing themselves for the semi-structured interviews. The interviewer went through each set of responses from interviews and reviewed them, looking for recurring themes and labelled said themes with commenting tools to categorize them. The language usage in the transcriptions was maintained as spoken by participants in order to avoid appropriating participants' intended meanings. As a result, the authenticity of the collected data is kept and representative quotes may contain non-standard English usage (Douglas, 2015). Pseudonyms were given to the participants who took part in the follow-up interviews, making sure to keep the participants' information confidential, especially during the coding, to eliminate as much bias as possible (Gay & Mills, 2016). Once the data had been transcribed, the researcher coded the information gathered from the follow-up interviews. The coded information was also transferred into tables in MS Word to compare the interviews and analyze them in further detail, allowing the researcher to develop overarching patterns and themes in accordance with the research questions and sub questions.

Related to each of the generated themes, the researcher created narratives of each individual participant's experiences while bracketing her own interpretation until the discussion stage of the analysis. At this point, it is important to note that the researcher herself was a qualified teacher in a Canadian offshore school in China for four years, and in general she thinks this educational approach has some merit. While she was a teacher in a Canadian offshore school, she met many colleagues who were also teaching in CLIL classrooms. The participants were recruited from these colleagues. Colleagues can be a useful source of information, because, according to Tillman-Healy (2003), colleagues can provide reliable and trustworthy data. The fact that the researcher was a teacher in a Canadian offshore school and had a relationship with the participants may influence the findings. Guba (1981) referred to this type of acknowledgement as reflexivity. For Guba, reflexivity involves revealing underlying points of view and understandings on purpose to understand how the researcher's lived experiences may influence the data collection and analysis. Having said that, the researcher did try to be as objective and unbiased as possible during her research activities.

3.9 Validity

Validity was supported in this study through triangulation. Both an email questionnaire and interviews were used as a means of triangulation in this study. The researcher's supervisor also reviewed the completed thematic coding which contributed to the validity of the research findings. Some examples of codes used to analyze the data include: students' evaluation, teaching schedule, teaching requirement, language acquisition, language proficiency, and students' future development. The results were then analyzed after the conducting of the literature review. The researcher reviewed and discussed the research questions, email questionnaire, and interviews with her supervisor multiple times to create the most accessible information as possible. The information from both the questionnaires and interviews was then compiled, coded, and compared as the findings emerged within the study.

Despite all these precautions, the fact that the study was conducted at only one Canadian offshore school means that the validity of the study is much less, thus the findings are not generalizable. In order to improve validity, further research conducted at other secondary schools, with a wider range of participants would provide stronger validity in the findings for a study similar to the current research.

3.10 Trustworthiness

Trustworthiness for this study was addressed in several ways. First, detailed procedural information was provided in order to clearly explain how the study was conducted, the setting for the study, and who the participants were. Second, factual accuracy of the data was ensured. Questionnaires were gathered through email and the interviews were transcribed word for word and the transcripts verified by emailing them to each of the participants, thus making the data gathering process more transparent. All quotes were taken directly from interview responses. Interpretations were based on researcher's perceptions with particular attention paid to a qualitative approach informed by phenomenological processes (Creswell, 1998). In addition, in the data analysis, triangulation of the email questionnaire and the interview responses contributed to the examining and cross-checking of the consistency of the findings (Gay, Mills, & Airasian, 2012).

3.11 Reliability

The procedures of this study have been described in great detail above in the data gathering part of this chapter. Inherent bias and error were recognized as a possible factor in this study. With the detailed information described, other researchers would be able to replicate the study, although results may differ. Although certain factors cannot be controlled, further studies would be necessary to help create a compare and contrast with this study if working with other outlying factors, such as a different school, more participants, or different first languages.

3.12 Concluding Remarks for Chapter 3

This study was designed to analyze teachers' perceptions of the impacts of CLIL on mathematical critical thinking development in Canadian offshore schools through various aspects. Qualitative research methods influenced by a phenomenological tradition were used and the research instruments included both an email questionnaire and in-depth semi-structured interviews specifically developed for this study. An overarching research question was created in order to direct the focus of the study. This was a low risk, confidential, and voluntary study from which the participants could drop out at any time. The next chapter (chapter 4) will discuss the findings and the results of the research study.

Chapter 4 Results Chapter

4.1 Overview of Chapter 4

Chapter four discusses the results of the research conducted by the investigator. This chapter reports the results from both the email questionnaires and interviews. At the time of the study, all of the participants were current or former teachers with recent experience within the past two years teaching secondary mathematics in Canadian offshore schools. As such, the participants were able to discuss their perceptions as practitioners. This chapter will present the results of the study in two sections. First, the demographic information for the survey is explained and in the next, the findings from the interviews are discussed. Representative quoted responses were used to represent the interview data.

4.2 Survey Data Findings

There were seven participants in total who completed the email questionnaire. The email questionnaire (See Appendix C) was created in advance by the researcher. It had four sections. The first section was about informed consent and all participants checked off ‘yes’ to participate in the email questionnaire part. The second section included six demographic questions related to age, country of origin, first language identification, teacher certification, length of teaching experience, and teaching grades. All of them had at least three years’ relevant teaching experience. When mentioning their home countries and first languages: Six of the participants were of Chinese nationality with Mandarin as the first language and English as the additional language, one of the participants was from Canada with English as the first language and he never learned Chinese before he came to China. The six Chinese teachers received their secondary mathematics teacher certificates in China and the Canadian teacher received his teacher certificate in New Brunswick in Canada. All of them taught high school mathematics, from G10 to G12. More detailed demographic information can be found in Chapter 3, Table 3.1. The third section was titled “short answer questions”, consisting of nine questions developed around mathematical critical thinking and CLIL. Since participants answered this section in only a few words, such as ‘yes’ or ‘no’, ‘important’ or ‘not important’, and all participants provided their consent in the fourth section to take part in the interview part, the researcher used the nine questions in the third section as guiding questions for participants to do the follow-up interviews. In other words, the nine questions were similar in the semi-structured interviews to the questions on the questionnaire. These questions were developed to gather data to answer the overarching research question along with the sub-questions. However, the questions were not developed with preconceived themes or categories in mind. The themes arose later out of the gathered data. Thus, the nine questions were asked again in the semi-structured interviews and detailed information was collected in those interviews. Please note that since the questionnaire had the main purpose as acting as a prompt to activate background knowledge for the later interviews, the results from the third section of the questionnaire are reported in conjunction with the interview results to support the interview findings. This contributed to the reliability of the themes that arose in the data.

4.3 Interview Data Findings

This section discusses the interview results initially. The participants who took part in interviews were the same with those who completed the email questionnaires. Relying on a qualitative approach to analyzing the data, the results next reported were found through the coding and categorizing of meaningful data units in the participant interview responses. Participant responses were examined for units of meaning. Units of meaning are phrases or sentences that can informatively stand on their own and be assigned a code (Creswell, 1998). The units of meaning were not predetermined. The thematic analysis consisted of each unit of meaning being coded and then categorized. As these categories converged, themes emerged from the data. Three key emergent themes were reported with a number of subthemes: critical thinking in mathematics, CLIL in secondary mathematics classroom, and CLIL and critical thinking in mathematics. These themes were not pre-identified. Rather, once the themes began to emerge, the literature review was revisited to explore other research related to the emerging themes. The entire approach was an iterative process that involved reading and re-reading the data, exploring the literature, continuing the analysis until a saturation point was reached and the themes could no longer be developed. The emergent themes have been presented in this section without extensive analysis as to capture the authentic perceptions of the participants. The discussion chapter will continue to analyze and elaborate on the results to explore the impact of CLIL on critical thinking development in secondary mathematics classrooms. Figure 4.1 below is a diagram describing all the themes and subthemes in the interview data.

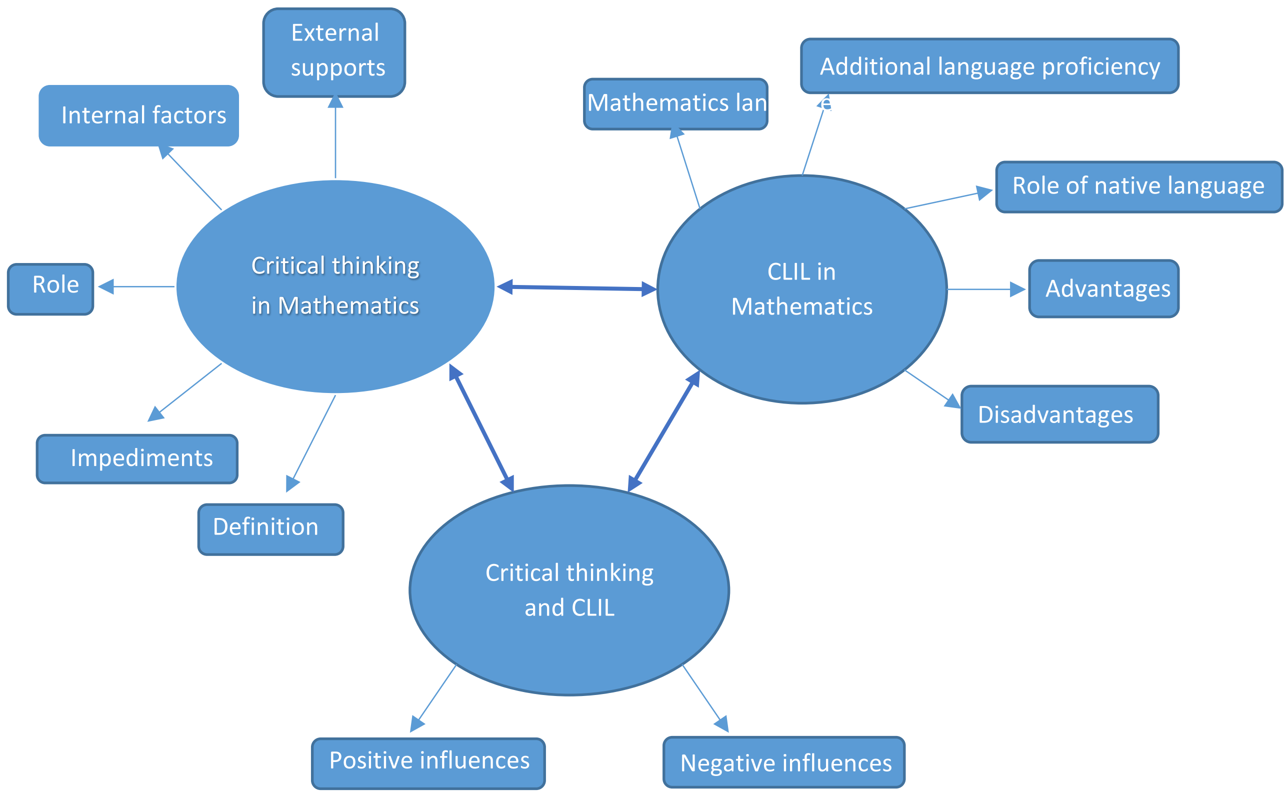

Figure 4.1 Themes and subthemes in interview data

4.3.1 Theme 1: Critical thinking in Mathematics

The first theme to emerge from the data related to the research question was critical thinking in mathematics. The major subthemes that emerged throughout the overall category of critical thinking in mathematics were: definition of mathematical critical thinking, the role of mathematical critical thinking, impediments to develop critical thinking, external supports to promote critical thinking, and internal factors that affect critical thinking development in mathematics.

4.3.1.1 Subtheme 1: Definition of Critical Thinking in Mathematics

The first major subtheme connected to the theme of critical thinking is related to the definition of critical thinking. Participants mentioned a number of characteristics when talking about the definition of critical thinking. These characteristics were about thinking from various perspectives, ability to analyze problems dialectically, reflective thinking, logical thinking, ability to apply prior knowledge, and thinking habits. Figure 4.2 below is a diagram describing subtheme 1:

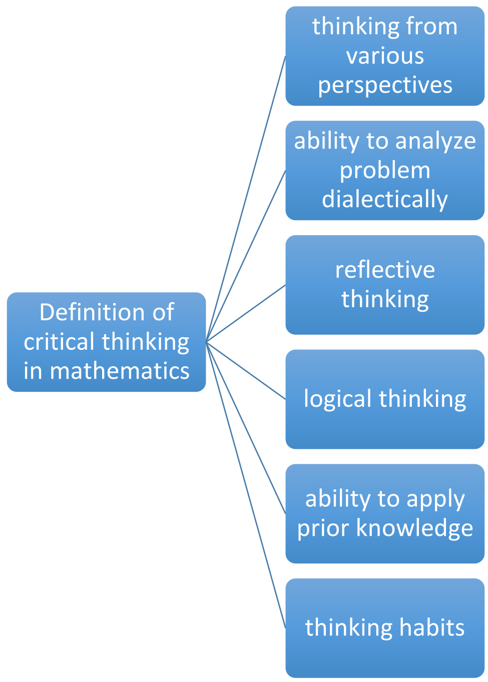

Figure 4.2 Definition of critical thinking in mathematics

Four participants identified that critical thinking was about thinking from various perspectives. For example, Wang thought that critical thinking in mathematics was "analyzing a problem using various methods" in his questionnaire and he elaborated with an example in his interview that "a student solving a mathematics problem should be able to understand it pictorially, verbally, and analytically." Yi felt that critical thinking in mathematics would be "to view, analyze, or learn mathematic knowledge in various ways." Sara and Liu also pointed out that critical thinking was about thinking about problems "from different aspects" and "from different angles" in their questionnaire responses, respectively. Sara explained further in her interview with an example:

> To find out the monotonicity of a function in a certain domain, it has several ways to address it. First, students could draw the graph of the function and get the answers graphically. Second, students could use the definition of monotonicity to prove their answers. Third, students could find the monotonic intervals through finding the derivative of the function. Students should try to solve a problem through thinking from different ways and aspects.

Two participants said that critical thinking was about analyzing problems dialectically, which means analyzing problems objectively, comprehensively, developmentally, and connectively. For example, Ma found that critical thinking in mathematics was "analyzing problems dialectically when studying, exploring and addressing [them]" and Liu felt that students need to "analyze a problem dialectically, and [teachers need to] teach students not to just take what teachers said blindly and learn to think by themselves."

Three participants verified the role of reflection in mathematical critical thinking in their questionnaires and interviews. For example, Sara thought that students and teachers should "have the habit of reflectively thinking" and Mei felt that critical thinking in mathematics required students "to do reflection constantly during the process of learning new knowledge through analysis, inference, questioning and thinking."

Three participants felt that logical thinking was the basis for critical thinking in mathematics in their questionnaires and interviews. For example, Li said that students need to "analyze questions reasonably, based on fact and logic" and Ma also felt critical thinking was a kind of "reasonable, logical thinking"; Yi mentioned that it was "to develop logic thinking skills when learning mathematics knowledge."

Two participants also mentioned applying prior knowledge when taking about critical thinking in mathematics in their interviews. For example, Yi and Sara thought that critical thinking was to "use prior mathematics knowledge to address unknown problems or situations" and build "bridges between unknown knowledge and prior knowledge."

Only one participant, Ma, pointed out that critical thinking in mathematics was not only thinking ability but also about thinking habits, as critical thinking included "both thinking skills and thinking propositions."

4.3.1.2 Subtheme 2: The Role of Mathematical Critical Thinking

The second major subtheme connected to the theme of critical thinking is related to the role of mathematical critical thinking. All participants, in their questionnaires and interviews, confirmed the importance of developing critical thinking in mathematics in high schools. For example, Liu said, in her interview:

> critical thinking could broaden students' thinking and horizon, during the process of developing students' critical thinking, students could learn using different methods to analyze the same problem, which could help a lot in their mathematics learning process and in addressing problems.

Mei felt that critical thinking was "really important not only for students to gain good academic achievement, it will help a lot after students go to university during self-study. High school is a really good stage for them to develop their thinking skills." Sara also thought that "Students learn a lot of knowledge in high schools and it is an important stage for them to learn all kinds of thinking skills. High school mathematics is the base of some other subjects." Yi answered "as a kind of thinking method and ability, it is more important in high schools since students assume lots of knowledge and thinking abilities in the stage." Ma mentioned the importance of mathematical critical thinking by saying that "only with critical thinking, students could take active to analyze and address problems. At the same time, they will have the habit or proposition to think more about problems and then to explore ways to address problems." Li also found that it was "a necessary thinking competence for learners or even people. Only with critical thinking, people can think independently, analyze problems and make good decisions to address problems."

4.3.1.3 Subtheme 3: Impediments to Developing Critical Thinking

The third major subtheme connected to the theme of critical thinking is related to factors that impeded the development of critical thinking. The participants identified a number of impediments to promoting their students' critical thinking in their mathematics classrooms. These impediments included a lack of instructional time, a lack of resources, and defects in the evaluation system. Figure 4.3 below is a diagram describing subtheme 3:

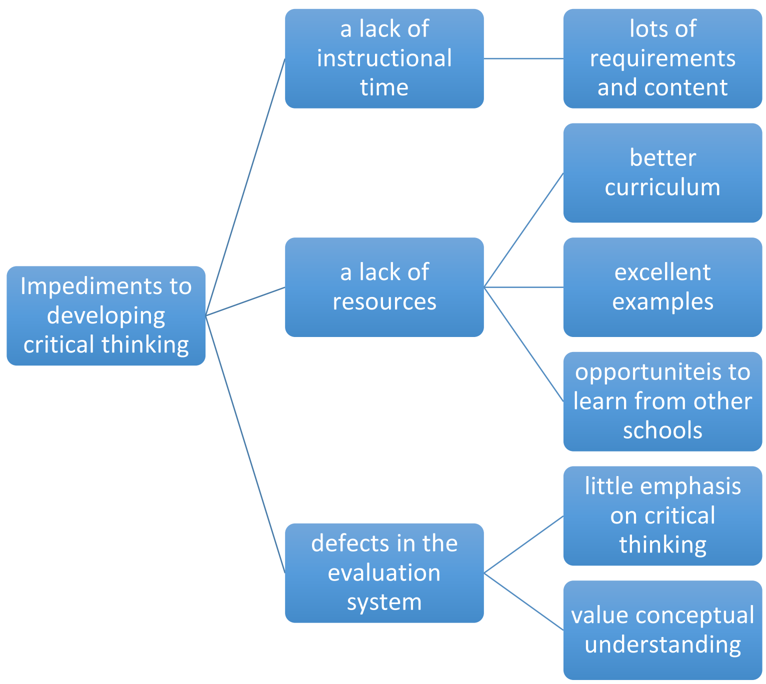

Figure 4.3 Impediments to developing critical thinking

Some impediments were associated with a lack of instructional time and a lack of resources. For example, Liu thought that teachers were “limited by [our] instructional requirement and task and time is not enough.” Wang found that he “wasn’t given enough instructional time to fully develop students’ abilities.” Yi also felt that teachers did not “have enough instructional time and [they had] plenty of study content to complete,” and he added schools should introduce better curriculum with more emphasis on critical thinking, such as the IB (International Baccalaureate) curriculum. Sara and Mei mentioned, in their questionnaires, that they did not get enough opportunities to promote students’ critical thinking. Sara expressed in her interview that she did not have enough opportunities to develop critical thinking “because of many factors, for example, instructional time and requirement, [which made] teachers tend to put emphasis on finishing content” and teachers did not “have enough resources to learn about how to promote students’ critical thinking.” She said schools should provide teachers with more excellent examples and opportunities to go to other schools to observe to learn how to promote critical thinking

Another big impediment was about students’ evaluation system. Li pointed out that students’ evaluation system “cannot promote critical thinking really well.” In her interview, Mei reinforced Li’s opinion when she said there was “no much mathematical thinking skills requirements and training in [students’ evaluation], which resulted in students’ lack of understanding and thinking” and teachers tended to “develop more about students’ grasp of conceptual knowledge, formulas’ memorization and direct application of formulas” rather than students’ critical thinking. Wang also felt that students tended to “learn solving problems conceptually which is enough to get scores [in evaluation] rather than getting trained their critical thinking.” Sara added that students’ evaluation system might “affect teachers’ [teaching] emphasis and methods to help students get good score and make students only value conceptual understanding of knowledge [rather than critical thinking development."

4.3.1.4 Subtheme 4: External Supports to Develop Critical Thinking

The fourth major subtheme connected to the theme of critical thinking is related to external supports that develop critical thinking. Participants indicated there were several external factors that supported the development of students' critical thinking skills in their mathematics classrooms. External supports here mean factors outside of the classroom that could facilitate critical thinking development, such as school resources, curricula, evaluation systems, and schedules. In the interview data, these supports included the students' evaluation system and specific curriculum in Canadian offshore schools. Figure 4.4 below is a diagram describing subtheme 4:

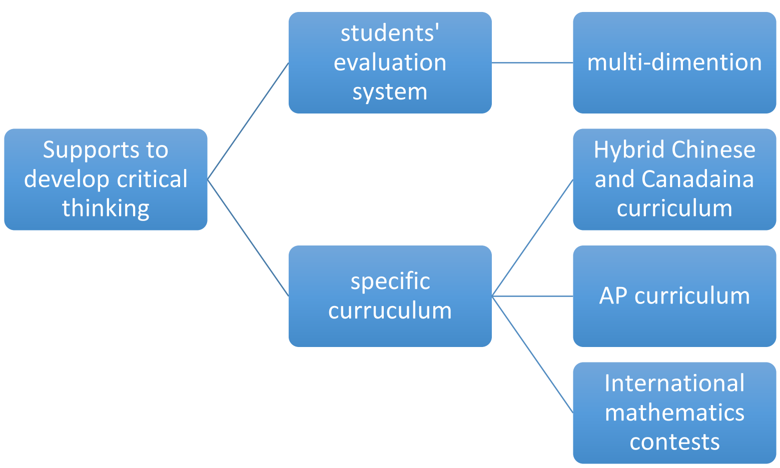

Figure 4.4 Supports to develop critical thinking

Yi and Liu both thought, in their questionnaires, that the students' evaluation system has positive effects on promoting students' critical thinking. They provided detailed explanations in their interviews. Yi thought the evaluation system was from a Western point of view when she indicated, "in students' evaluation, grades on papers are not the only factor, it has multidimensional evaluation system, including students' class performance and assignment." Liu said the evaluation was far better than that in public schools, "our evaluation system is also a kind of reform, [and it has] different standards on evaluating students and is consisted of different factors, which also entail promoting students' critical thinking."

Five participants mentioned the positive role of specific aspects in the curriculum in promoting students' critical thinking. Liu thought that the Chinese mathematics curriculum was "after education reform and designed to promote students' critical thinking in some ways, such as our teaching methods" and AP curriculum was "a kind of Western curriculum, which put more emphasis on students' critical thinking development." She illustrated with an example that she was writing a textbook for middle school students and she felt that in that book teaching was "transferring from passing knowledge to students to leading students to learn and create." Sara found that the mathematics curriculum could "show more development of critical thinking than traditional teaching in [Canadian offshore schools], but still need more effort" and AP curriculum could "promote students' critical thinking better since AP test puts the emphasis on testing students' thinking skills." Yi also felt curriculum "has critical thinking during the process of establishing bilingual mathematics curriculum system which has both eastern and western characteristics" by integrating international curriculum resource. Ma mentioned that especially AP curriculum "could promote students' abilities of analyzing and addressing problems, [and it could be seen] from students' achievements of international contests and AP tests." Li added that international contests "could promote students' critical thinking" since they put more emphasis on testing students' thinking skills.

4.3.1.5 Subtheme 5: Internal Factors Affecting Students' Critical Thinking in the CLIL Mathematics Classroom

The fifth major subtheme connected to the theme of critical thinking is related to the internal factors affecting students' critical thinking in CLIL mathematics classrooms. Participants identified a number of internal factors that have an influence on developing students' critical thinking abilities. Internal factors here mean factors within the classroom, such as teachers' English language proficiency, students' learning attitude and interest, and the teaching methods. In the interviews, these factors were associated with teaching methods, CLIL, academic performance, additional language proficiency, motivation, and interest. The influences of CLIL was previously discussed in subtheme 3 above. Figure 4.5 below is a diagram describing subtheme 5:

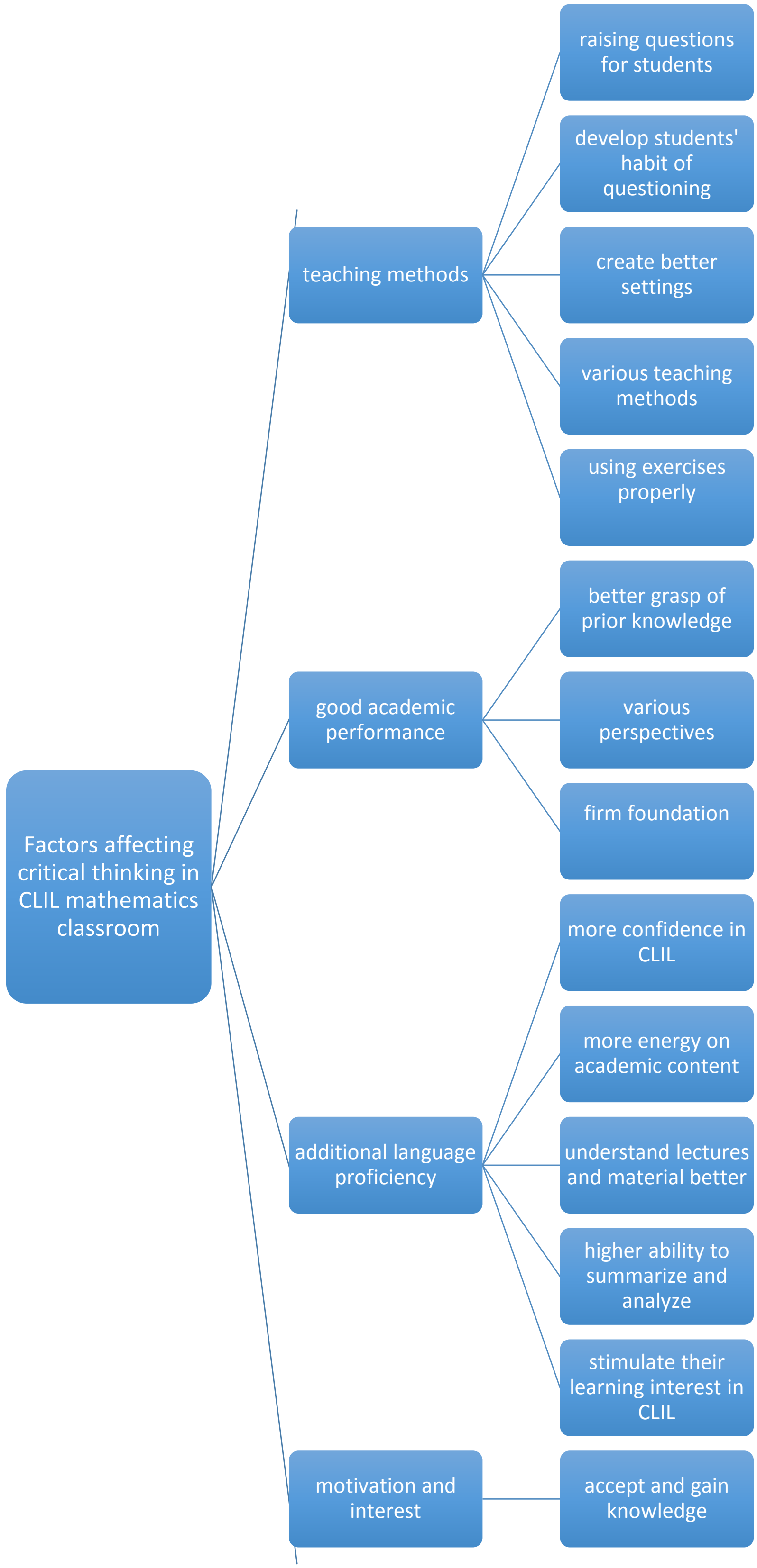

Figure 4.5 Factors affecting students' critical thinking in CLIL mathematics classroom

All the participants acknowledged the role of teaching methods in critical thinking development. For example, in her questionnaire, Li thought that teachers could develop students' critical thinking by adopting appropriate teaching methods. As to how to adopt appropriate teaching methods to promote critical thinking, She said in her interview:

> For critical thinking in high school, teachers ask students questions purposely during addressing problems. Through raising questions for students, to try expose students' thinking mistakes and help them realize how to treat mistakes and think better next time, to try to stimulate students' thinking. Teachers could promote students' thinking through raising good questions to them, [though] encouraging students to think more and rigorously, make logical inference, do reflective thinking after learning, teaching them how to make questioning.

In his questionnaire, Ma felt students' critical thinking development was related to "teachers' teaching methods" and "teachers should adjust or create settings to promote critical thinking." He elaborated on this opinion with an example:

> In Geometry, when studying about the relations between line and line, line and plane, plane and plane. To a certain problem, I use different methods to teach students. To find a volume of an object is a typical problem in Geometry. I use both three vertical theorem and spatial vector to show students how we address the same problems with different methods. Moreover, after addressing the problem, I ask students to do reflection. There is one example happened in my classroom. There is one time, after we found out the volume of a solid successfully, I asked students to think more about the problem and they found that the answer was contradictive with the setting of the problem.

Moreover, he thought that teachers "could adjust time to promote students' critical thinking." He gave an example: "for one comprehensible problem, it might take a whole class to address it clearly since it integrates lots of points together and it is a good chance to develop students' critical thinking. At this situation, teachers cannot just use 10 minutes on it." Wang, in his questionnaire, found critical thinking was "developed through methods used by teachers" and he gave an example by saying that teachers could alter their expressions to make students understand better. Yi also pointed out the key point was on "how teachers emphasize the development of students' critical thinking in practice… and methods teachers use to promote it." In their questionnaires, Sara said that she could promote students' critical thinking through designing exercises, and Mei expressed the idea that she could lead students to ask questions. They talked specifically about how they use these methods in their interviews. Sara said:

> After teaching, I could give students a comprehensive problem for them to address. In this comprehensible problem, students get the opportunity to think, to analyze, to try to relate their prior knowledge to the situation, to find assumptions and questions.

Mei said she "always lead students to ask questions and 'why', [since] it could help to improve students' ability to find out assumptions, analyze problems, logical thinking, apply prior knowledge to addressing new situations" and she also mentioned that she could "design some "traps" when teaching applications of knowledge in order to let students do more reflection, so students would have the habit to think critically when meeting with problems." In addition, for those students who are good at questioning, she could "encourage and affirm them in my classroom in order to develop other students' habit of questioning." Liu also thought that teaching methods play an important role in promoting critical thinking and she provided an example about how she used different teaching methods to promote critical thinking. She furthered with an example:

> In teaching triangular functions and formulas, I do not want students to memorize it. I put my emphasis on the processing how students get the formulas. I teach students to address problems directly using graphs so that they can learn to analyze problems by themselves rather than relying on memorizing formulas.

As to academic performance, all participants thought it was related with students' critical thinking development and some participants felt these two factors were intertwined with each other. They explained their opinions in their interviews. Mei thought:

> Students with better academic performance would have stronger mathematical critical thinking generally, [they] would have better grasp and digestion about prior knowledge, which could help their mathematical critical thinking development later.

Yi and Sara mentioned that students with better academic performance "will gain critical thinking easier if they are trained purposely" and "have better foundation and better critical thinking," respectively. Wang found that students with high academic performance "may show higher critical thinking typically" and Ma also felt those students "tend to have stronger mathematics critical thinking in general." Ma further said:

> Students with better academic performance would have better mathematics foundations, [they] have different start points and perspectives when they consider about questions. They will consider about questions from various points or aspects. So their understanding ability and analysis ability will be better relatively and also mathematical critical thinking.

Li thought students with better academic performance have “better knowledge foundation, which is the base of thinking and could broad their development of critical thinking.” Liu added that those students would “have wider perspectives and methods to analyze problems and tend to have stronger critical thinking abilities.”

Five participants, in their questionnaires, confirmed the role of students’ English proficiency in developing students’ critical thinking. They furthered on this idea in the interviews. Mei found that students with better English would “help their mathematics critical thinking development.” She elaborated:

> They [students] would have more confidence about learning in CLIL and they can put more energy and attention on gaining academic knowledge, developing thinking skills and thinking instead of trying to understand what teachers are saying.”

Yi felt students with better English proficiency “would understand questions and textbook more easily, they can express themselves and understand teacher better, [it could] enhance students’ proposition of critical thinking.” He also thought those students “could have better development of critical thinking because it will influence their learning interest, motivation in CLIL indirectly” and they may have “lower learning difficulty in CLIL.” Ma said “it has great help to their development of critical thinking if their English gets better.” Li also pointed out that students with better English proficiency tended to be “good at thinking, analyzing and summarizing, and they can understand knowledge and textbook more easily, [which are] helpful to their critical thinking development.” Sara mentioned students with better English would have higher “self-study ability, which would stimulate their learning interest and open their learning area.” She gave one example:

> Students with good English level could learn AP courses and take part in international contest, their outcomes from those could stimulate their learning and interest too. Understanding ability, interest and their initiatives have great influence on their learning and development of critical thinking.

Yi mentioned the role of students' learning attitude and motivation in critical thinking development. He said:

> Students' learning attitude and motivation is directly related to their learning process, achievement and critical thinking development. Students' learning interest and motivation will help them to accept and gain knowledge, the process of accepting and gaining knowledge is tightly related to their critical thinking development.

4.3.2 Theme 2: CLIL in High School Mathematics in Canadian Offshore Schools

The second theme related to the research questions was CLIL in mathematics. The major subthemes noticed throughout the overall category of CLIL in Mathematics were students' additional language proficiency, the role of first language, mathematics language, disadvantages of CLIL, and advantages of CLIL.

4.3.2.1 Subtheme 1: Additional Language Proficiency in the CLIL Mathematics Classroom

The first major subtheme connected to the theme of CLIL in mathematics classrooms is related to additional language proficiency. Participants discussed the requirement and influence of additional language proficiency when adopting CLIL in mathematics classrooms. In their questionnaires, Sara and Mei mentioned that students' additional language proficiency could affect their mathematics learning in CLIL. Yi, Ma, and Li found that students with good enough additional language abilities would not be restricted by the instructional language in their CLIL mathematics learning. In interviews, they furthered their explanations. Sara felt that "students should reach a certain English level to accept CLIL" since language did play an important role in their learning as a medium of understanding. She added that "students should reach 5.5 in their International English Language Test System (IELTS)" since mathematics has its own language. Liu thought students should reach "IELTS 5 to understand questions and exercises." Mei found that "English proficiency plays a really important role in students' mathematics learning in CLIL … students should have IELTS 6 and have some mathematics terminologies to accept CLIL." Yi pointed out "if students English level is really low, it will influence their learning significantly since they cannot understand teachers' lecture and read textbook and exercises." More specifically, he said for learning mathematics subject in English, students need IELTS 5. Li mentioned that students "should reach overall band 6.5 in IELTS to fully accept CLIL in mathematics," which means that they would not be restricted to learn mathematics in CLIL by their English level. Wang also stated his opinion: "students' English levels do play a role. A student who is weak in English will generally have a tougher time with a course taught in English. Students don't need much of an English back ground although it is helpful for certain topics. They should be familiar with their numbers, basic operations, and conditional statements."

4.3.2.2 Subtheme 2: The Role of First Language in the CLIL Mathematics Classroom

The second major subtheme connected to the theme of CLIL in mathematics classrooms is related to first language proficiency. It appeared in the data that the stronger students' Chinese language abilities, their first language, the better they were able learn in a CLIL classroom. All participants identified, in their questionnaires, the important role of first language use in the CLIL mathematics classroom. For example, Sara thought first language use was essential for teachers and students and Wang thought it was important but not essential. They elaborated in their interviews. Ma said, “for those students with bad English, Chinese helps them a lot and it is effective,” and students should “have some first language to help learning [in CLIL]” because of their English limits. He added that teachers “need to give students time to suit and accept CLIL,” and “the use of first language could become less and less after long time’s learning.” For those students with good English, he felt that the role of first language “is not so important.” Ma also explained that about 20% students in his class could not accept CLIL at all. Li felt that using the Chinese language provided little help for those students with really good English, but it “could help them a lot if students’ English is bad, because language’s help lies in helping students understand knowledge in a short time.” Liu also thought first language “could help students understand rightly and efficiently, [and] first language’s aid can enhance instructional outcome.” Sara pointed out that with the help of the Chinese language, students could “understand mathematics terminologies properly and understand lectures faster.” For some students, the first language’s aid also “gave them confidence” in learning mathematics in CLIL. She elaborated with an example:

> some students they do try their best to learn mathematics in CLIL, however, because of their English limit, they just cannot grasp meanings of some terminologies and theorems. Without the help of Chinese, they may become worse and worse in mathematics and lose their confidence and interest.

Li felt that the first language use was conditionally necessary; she thought that if students’ English was good enough, then they did not need first language’s help. Wang said the first language was not only necessary for students, but also for teachers if teachers could not alter their mode of expression to suit students' English language levels to make them understand lectures.

4.3.2.3 Subtheme 3: Mathematics Language

The third major subtheme connected to the theme of CLIL in mathematics classrooms is related to mathematics specific language. Participants confirmed that English used in CLIL mathematics classrooms was different from English used in daily life or English language classes since Mathematics had its own language. Yi thought students did not have to obtain a high English language proficiency to learn mathematics in CLIL "since mathematics has its own language and logic." Wang explained this idea a bit further:

> I consider mathematics a language by itself. It has its own grammar, and its own set of rules. Mathematics is an international language that everyone can understand. There are big differences [between English used in mathematics and general English]. Typically, English in mathematics is very specific, and almost unnatural. However, it does have applications to daily conversation. Particularly when studying logic in mathematics.

Sara also felt that if students could understand mathematics language in English, "such as many mathematics terminologies, notations and expressions, and students have firm fundamental knowledge, they will be okay to learn mathematics in English." She elaborated with an example: "The inference of derivative formulas: if students have proper understanding of limit and functions, then they can get those derivative formulas since the whole process is in mathematics language." Liu pointed out that it was really different for students to learn English in mathematics class and in general English class and she thought, "the settings are totally different, [and] mathematics language [in English] is different from daily lives' English."

4.3.2.4 Subtheme 4: Disadvantages of CLIL

The fourth major subtheme connected to the theme of CLIL in mathematics classrooms is related to the disadvantages of CLIL. Participants mentioned that CLIL had sometimes had a negative influence on teaching and learning in their questionnaires. For example, Sara said that it decreased students' academic knowledge gain and Wang felt that students' could not understand lectures because of their English level limit and teachers' pronunciation. They further explained these disadvantages as related to CLIL in mathematics classrooms in their interviews. These disadvantages were connected to schedules, teaching quality, difficulty in instruction, learning motivation, academic achievement, and students' learning process. Figure 4.5 below is a diagram describing subtheme 4.

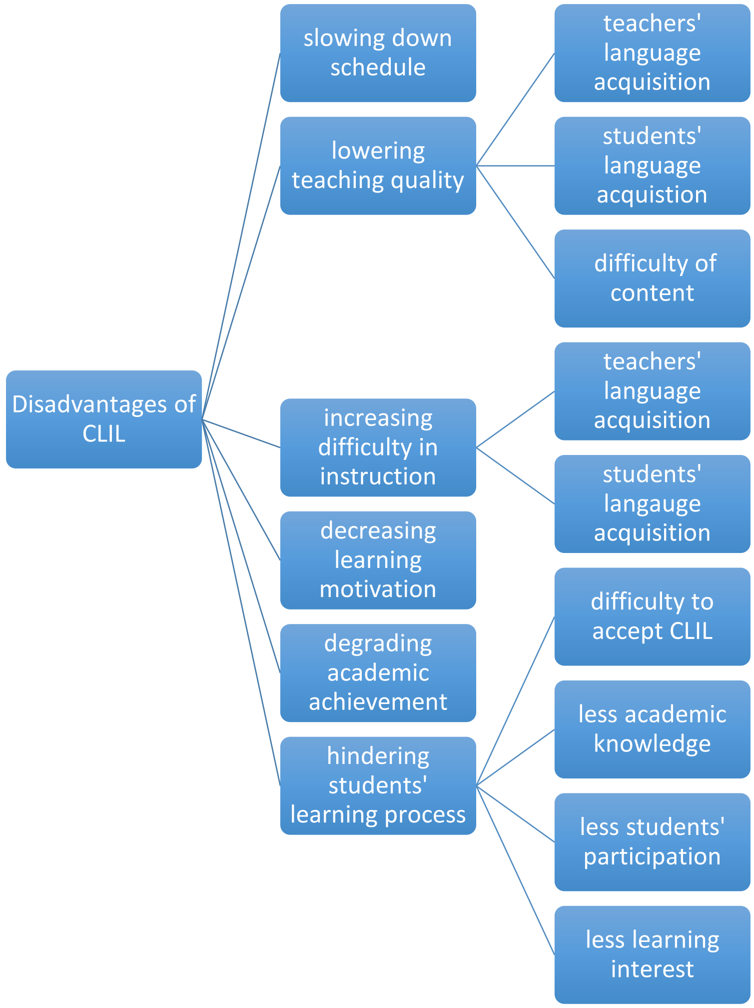

Figure 4.6 Disadvantages of CLIL

Four participants held the opinion that CLIL in mathematics could slow down the teaching schedule. Liu said, “students need time to translate English into the first language to understand textbooks and exercises, which take lots of time and slow down teaching.” Sara also felt that CLIL might slow down teaching because “students’ understanding with English is slower than their mother tongue, they need more time to understand teachers’ lecture.” Mei thought because “students need time to accumulate words and expressions in mathematics” and “students need time to adapt to this kind of learning”, CLIL slowed down her teaching. Yi also pointed out the same effects of the disadvantages of CLIL on his teaching.

Five participants discussed how CLIL in mathematics would reduce teaching quality. Liu said, “Teachers are trying to use language to help students understand knowledge, but with CLIL, some teachers might not express themselves as good as the first language. Moreover, students may feel disappointed when they feel they cannot express themselves really well in English to participate in activities, all these could influence teaching quality.” However, she added that she “would not change teaching content to suit students’ English level since I think student can always learn about English but they can only learn high school mathematics in high schools.” Ma thought that he would “adjust the difficulty and depth of exercise because of the limit of language.” Yi felt that it was possible that he would “decrease the difficulty of exercises.” Sara mentioned that she may “decrease the difficulty of content” because of students’ language level. She also said that students’ participation in activities and answering questions decreased in CLIL classrooms.

Two participants mentioned that they faced more difficulty in their instruction. Liu explained, “because English is not our first language, to use it as a medium of instruction is difficult for teachers sometimes, I feel it is difficult to express myself clearly sometimes and need Chinese to help me.” Wang said he would “try to speak English to students based on their level.” He provided an example: “I could try to speak at an overall low level when addressing the class, [and] when speaking one to one or in small groups, I could adjust my language based on to whom I was speaking.”

Three participants talked about the possible negative effects of CLIL on students’ learning motivation. Sara found that CLIL might result in students’ loss of confidence or interest in learning. She elaborated:

> Some students they do try their best to learn mathematics in CLIL, however, because of their English limit, they just cannot grasp meanings of some terminologies and theorems…. they may become worse and worse in mathematics and lose their confidence and interest.

Li also felt that students “would lose their confidence in learning because of their language problems or understanding problems.” Ma said students would “lose their interest in mathematics because of language problems.”

Two participants thought that CLIL in mathematics had a negative impact on students’ academic achievement. Liu said that CLIL might have “some influence on students’ academic performance, especially for those students with bad English level.” She explained:

> One example is our international contests, if you translate the problems for students, most students like 80% could gain prizes. If you use English problems, they spend most of time on checking dictionary to find out the meaning of the problems.

Mei also felt that CLIL might affect students’ academic achievement. She elaborated:

> students need time to adapt to the new learning environment and they need spend some energy on improving their English when learning about new knowledge, so in the same time period, the academic knowledge they gained may decrease and this might have influence on their academic achievement.

Almost all the participants felt that CLIL in mathematics had some negative influences on students’ learning process. For example, Liu found that students had “some difficulties to accept CLIL.” She explained:

> Some students’ English is not good to learn in CLIL, they have big difficulty in understanding lectures and textbooks. Some students’ English is good but they may mid-

understand textbooks and exercises because of specific mathematical expressions and different language structure, culture and expression habits. For example, students cannot tell the difference between ‘vertical’ and ‘perpendicular’, when learning about the equation of a line, it would make huge difference if they take vertical as perpendicular; when learning about asymptote in calculus, it is also a big mistake to take perpendicular as vertical. There are lots of other examples in international contests.

Mei felt that the academic knowledge students gained “may decrease during the same period, [since] students need to spend time and energy on learning English while learning mathematics.” She added that CLIL could also affect students’ learning “through affecting their participation in class and some students with low English level would not understand teachers’ lectures really well.” Sara thought students who didn’t like mathematics much and had bad English may “lose their learning interest totally because of CLIL, since they do not have initiatives in learning mathematics, language becomes a big barrier for them.” Wang said that students “may not understand the purpose or meaning of a certain mathematics exercise” if they “have trouble with English” in CLIL. Ma mentioned that “if students cannot understand teachers’ instruction because of their English level, [CLIL] would have big negative influence in their study.” Li pointed out that students may “have some difficulty in accepting CLIL because of the influence of our first language in understanding problems and thinking patterns.”

4.3.2.5 Subtheme 5: Advantages of CLIL

The fifth major subtheme connected to the theme of CLIL in mathematics classrooms is related to the advantages of CLIL. Participants confirmed several advantages that CLIL can have in mathematics classrooms. These advantages were associated with stimulating students’ learning motivation, advancing additional language acquisition, benefiting students’ future development, varying teaching methods, and helping students' learning. Figure 4.7 below is a diagram describing subtheme 5.

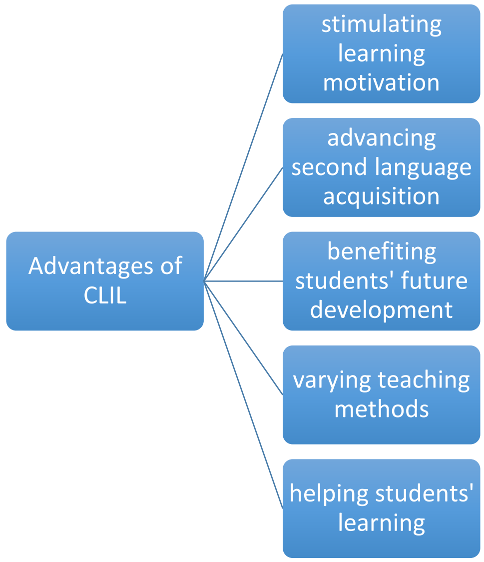

Figure 4.7 Advantages of CLIL

Five participants thought CLIL had positive effects on students' learning motivation. Liu found that CLIL "could enhance students' learning motivation." She said:

> Most students prefer to this kind of learning since they would further their study abroad and they feel they need to overcome language barrier and adapt to this kind of learning method as soon as possible.

Yi pointed out,

> Since students in [Canadian offshore schools] will [usually] go abroad to further their study, they may be induced to learn more in CLIL. It is beneficial to some students' learning attitude and could enhance their learning motivation.

Wang thought for students who were passionate about studying abroad and had an interest in mathematics, they would "have increased motivation to learn in a foreign language." Ma mentioned that for students whose English was good, CLIL would "stimulate their mathematics learning." Sara felt CLIL could "affect students' learning interest and motivation" and had "both negative sides and positive side on affecting students' learning."

Four participants identified the influence of CLIL on advancing students' additional language acquisition. Liu said that CLIL could "promote students' English, mainly in mathematics terminologies and expressions." Mei found that as students learned more and more in CLIL, they would "learn lots of mathematics terminologies and expressions, which is essential for them learn Mathematics in the instruction of English." Students' improvement in English, such as mathematics terminologies and expressions, could "help their learning in CLIL a lot no matter from enhancing their ability to understand teachers' lecture or decreasing their psychological barrier or increasing their confidence in the learning process." Yi found that one advantage of CLIL was "it could promote students' grasp of mathematics terminologies and understanding culture behind them." He elaborated,

> The name of The Pythagorean theorem. In China, BC 1120, people found that when the shorter leg in right triangle (we call it GOU in Chinese) is 3 and longer leg in right triangle is 4 (we call it GU in Chinese), then the hypotenuse will be 5. So we call this principle GOU GU theorem; In Western countries, about BC 572-492, Pythagorean in ancient Greek found this principle and proved it. So they call it Pythagorean theorem.

Wang said CLIL could improve students' English since "using a language, in any context, is beneficial to understanding the language."

Two participants thought CLIL could benefit students' future development. Liu felt that CLIL was good for students "from learning ability development and from their future study development" since "most of our students would further their study abroad. Wang thought that because “students at [Canadian offshore schools] are preparing for university in a foreign country, it is crucial for them to be exposed to as much mathematics based vocabulary.”

Two participants felt that CLIL could help students’ learning. Yi found that CLIIL could “help students contact with mathematics internationally, [for example], modern mathematics stems from western countries.” Li thought that CLIL had its own advantages on helping students’ learning. She explained, “Some English words can illustrate some knowledge or questions better.”

One participant, Liu, talked about the positive influences of CLIL in varying teaching methods. Liu said that teaching in CLIL “could have different teaching methods toward a same content since we refer to western textbooks when we teach in CLIL.” She elaborated:

> For example, in geometry, when we learn about geometric solids, western textbooks put more emphasis on relating our lives to our content. In learning hexagonal prisms, they use pencil as a model to teach students to learn about the superficial area and volume, students are excited and attracted to learn, it is easier for them to accept knowledge and develop their learning interest because they can feel the actual application of academic knowledge to our lives. There are lots of examples like this in CLIL. Teaching in CLIL could help teachers know about knowledge background, broaden our horizon and learn different teaching methods, in order to help students learn better.

4.3.3 Theme 3: CLIL and Critical Thinking Development in Mathematics

The third major theme related to CLIL and the development of critical thinking skills in mathematics. In the data, the participants discussed the influences of CLIL on students’ mathematical critical thinking development. Almost all participants thought that instructional language had no direct impacts on students’ critical thinking development in their questionnaires, just like mathematics was taught in English in some western countries and in Chinese in China. For example, Yi said that language had no direct relationship with mathematics learning and critical thinking. Wang said in his interview that mathematics was international and no matter what language it was taught, students could gain it and also mathematical critical thinking. However, as to the impacts of CLIL on critical thinking development in mathematics, some participants felt that CLIL could influence mathematical critical thinking development in some aspects, and these influences had both positive and negative sides. Figure 4.7 below is a diagram describing theme 3:

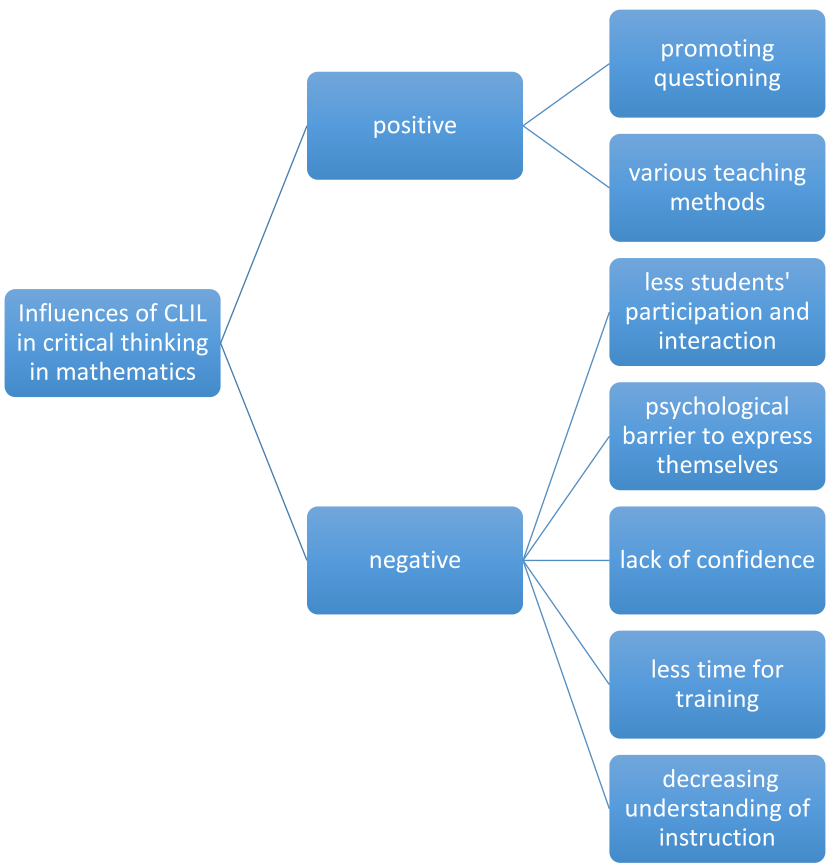

Figure 4.8 Influences of CLIL on critical thinking in mathematics

4.3.3.1 Subtheme 1: Positive Impacts on Critical Thinking Development

The first major subtheme connected to the theme of CLIL and the development of critical thinking in mathematics classrooms is related to the positive impacts of CLIL on critical thinking in mathematics. Li pointed out CLIL "could promote students' critical thinking development since it could promote students [to] think more and ask questions and questioning could help develop students' critical thinking." Liu felt CLIL could promote students' critical thinking since it "could broaden students' horizon and thinking by using different teaching methods and by comparing western teaching methods and our traditional teaching methods." She added that teachers could learn a lot in CLIL, such as different teaching methods, to promote critical thinking from western textbooks, and resources "since western countries put more emphasis on critical thinking development." She gave an example: "To find the values of a angle's trigonometric functions, western education put more emphasis on the reasoning process rather than memorizing the formulas."

4.3.3.2 Subtheme 2: Negative Impacts on Critical Thinking Development

The second major subtheme connected to the theme of CLIL and the development of critical thinking in mathematics classrooms is related to the negative impacts of CLIL on critical thinking in mathematics.Sara felt that the medium of instruction or language "could affect teachers' instructional methods and students' learning interest and motivation, which could affect their critical thinking development." Mei thought CLIL could affect students' critical thinking developments. She said:

> Because of language limit, students will have some psychological barriers when listening to teachers' lectures and asking questions; it may affect students' participation in activities or interaction with teachers, some students would choose not to ask questions

because their lack of confidence about their English expression and their participation decreases obviously in this kind of environment; moreover, students would put their attention on understand what teachers are saying instead of understanding academic knowledge that is conveyed by teachers' word. All these can affect their critical thinking development.

Sara mentioned that the influence of CLIL on critical thinking development was through its effects on instruction. She explained, "since teachers promote students' critical thinking through their instruction, if students cannot understand teachers' instruction, then their critical thinking cannot be developed."

4.4 Conclusion

The overarching research question in this study explored teachers' perceptions of the impacts of CLIL on critical thinking development in secondary mathematics in Canadian offshore schools. The data were gathered from an email questionnaire and semi-structured interviews. Three themes were found with several subthemes: critical thinking in mathematics, CLIL in mathematics, and critical thinking and CLIL. All of these themes were presented with the varying viewpoints of the participants, and illustrated with representative quotes from the data. However, a common pattern was seen throughout: CLIL has both negative and positive influences on critical thinking development in mathematics, in both direct and indirect ways. All the results in this chapter are discussed in next chapter accordingly (Chapter 5). By viewing the influences dialectically, educators can assist students by utilizing advantages found in this study and overcoming disadvantages related by the participants, that will in turn benefit their students' critical thinking development in the mathematics classroom.

Chapter 5 Discussion

5.1 Overview of the Study

This study focused on the impacts of CLIL on critical thinking in secondary mathematics development in Canadian offshore schools. The theoretical perspective positions CLIL as a constructivist approach to learning (Dalma, 2003), which can develop thinking skills (Hanesova, 2014). However, CLIL in secondary mathematics in Canadian offshore schools in China, particularly for the development of mathematical critical thinking, needs more exploration. This qualitative study is framed within a constructivist understanding of learning with influences from phenomenological research traditions. Additional language acquisition theory was used throughout the study as means of understanding the process of how additional languages are learned.

The purpose of this study was to better understand teachers' perceptions of the impacts of CLIL on critical thinking in secondary mathematics for students from linguistically diverse backgrounds in Canadian offshore schools, using both an email questionnaire and semi-structured interviews. Participants were teachers with current or recent experience working in Canadian offshore schools. Data were coded to find themes and subthemes prevalent throughout the investigation, finding parallels and connections between participants' answers (Gay, Mills, & Airasian, 2012).

Because of the qualitative nature of this study, the research hypothesis worked mainly as a guiding hypothesis, allowing it to work fluidly with the needs of the participants. It was assumed that CLIL might have some impacts on students' critical thinking development in secondary mathematics. In both the questionnaire and the interview data, the perceptions of the participants contributed to confirming this initial guiding hypothesis. As a result, it was put forward in this study that CLIL could affect students' mathematical critical thinking development both positively and negatively. CLIL, as understood in this study, was defined by Coyle, Hood and Marsh (2000) as "a dual-focused educational approach in which an additional language is used for the learning and teaching of both content and language (p. 1)." In the current study, the definition of mathematical critical thinking was based on Glazer's (2001) ideas related to this concept. Glazer felt that critical thinking in mathematics involved skills and dispositions related to solving mathematics problems reflectively.

To understand the results more thoroughly, the intent of this chapter is to interpret, analyze, and clarify the implications of some of these findings. This chapter will examine some major themes that arose in the data, as well as identify the limitations and biases that may have occurred in the study.

5.2 Summary of Results

The research topic in this research study was related to CLIL in secondary mathematics. Participants were asked what mathematical critical thinking was in their opinion, what CLIL was, and how CLIL could affect students' mathematical critical thinking. The results identified three major themes and multiple subthemes (with each theme).

5.3 Discussion of Results

5.3.1 Definition of Critical Thinking in Mathematics

The definition of critical thinking in mathematics in this study was based on Glazer's (2011) definition. A number of characteristics associated with this definition were mentioned with high frequency by participants in the data, such as the ability to apply prior knowledge, logical thinking, reflective thinking, and analyzing problems dialectically; however, only one participant thought that critical thinking was also about thinking habits or thinking dispositions. For many years, skills or abilities were the only objective in the teaching and assessment of critical thinking. Currently, however, it has been thought that dispositions or attitudes are also part of critical thinking (Ennis, 1987; Mcpeck, 1981). Dispositions are necessary since skills are not sufficient to enable a person to think critically if that person does not have the disposition or motivation to carry them out. People need to be disposed or motivated to exercise those skills in critical thinking. Therefore, it is really important for teachers to recognize the necessity of disposition in critical thinking and then to stimulate it as well as other abilities during their instruction.

5.3.2 The Role of Critical Thinking in Mathematics

The participants commonly agreed that critical thinking in mathematics is very important and should be promoted in the classroom. Critical thinking capabilities are crucial to one's success in the modern world, where making rational decisions is increasingly becoming a part of everyday life. For students in Canadian offshore schools, since those schools are mostly boarding schools and most students in those schools typically choose to further their study abroad, critical thinking skills and dispositions are beneficial for them to test reliability, raise doubts, investigate situations, and explore alternatives, both in school and in everyday life in secondary and post-secondary study. Moreover, critical thinking development is advocated in the education systems both in China and Canada. Chinese educational reform in the early 21st century has put more emphasis on students' development of thinking skills, aiming at transferring from an exam-oriented education to a qualifications-focused education, from a teacher-centered classroom to a student-centered classroom. The secondary mathematics curriculum in Canadian offshore schools is a hybrid Canadian and Chinese curriculum (Schuetze, 2008), which includes the ideas and goals of the development of critical thinking in the Canadian mathematics curriculum.

5.3.3 Impediments and Supports to Develop Critical Thinking.

There are many impediments and supports related to developing critical thinking in Canadian offshore schools. Related to the impediments, participants felt that limited instructional time and a large amount of content tasks decreased teachers' opportunities to develop critical thinking in their classrooms. The priority in teaching was about completing instructional content and helping students with exams, which could have a negative indirect influence on students' critical thinking development in the classroom. Due to time factors and exam pressures, teachers' pedagogical choices also could constrain and then impact on the kind of teaching and learning that take place in the mathematics classroom (Tan, 2011), which then could result in instruction with little critical thinking development.

Also in connection to the impediments, the specific curriculum and evaluation system in Canadian offshore schools are double-edged swords when it comes to the development of critical thinking. One the one hand, participants pointed out that schools lacked better curriculum to promote and assess critical thinking development, and on the other hand teachers did not receive effective professional development related to critical thinking in CLIL mathematics classroom. It appears that a systematic curriculum which integrates content learning and language learning still needs to be developed for Canadian offshore schools. Moreover, school resources available to teachers, such as the physical environment and teachers' professional development, could influence teachers' beliefs and values, which could then affect teachers' emphasis in teaching. A lack of professional development could decrease teachers' emphasis on critical thinking development and could result in teachers' lack of understanding of critical thinking, its importance, and approaches to promote it. Moreover, missing elements in the evaluation system, such as a lack of emphasis on critical thinking and valuing conceptual understanding in exams, were a kind of impediment to develop critical thinking. Students and teachers tended to neglect critical thinking development since it would not be tested in exams.

However, in the participants' opinion, AP curriculum, international contests which were introduced from western countries, and the hybrid secondary mathematics curriculum were more advanced than the current curriculum in Chinese public schools, and it was already on the road to integrating the notion of critical thinking development. A multidimentional evaluation system rather than evaluation through only exams gave teachers and students more opportunities to develop critical thinking. With the evaluation system in public high schools in China, teachers and students tend to put all their time and energy on passing the exams and no big change could happen to realize a competency based education (Yan, 2015), including critical thinking development. Figure 5.1 describes some of the impediments and supports related to critical thinking development.

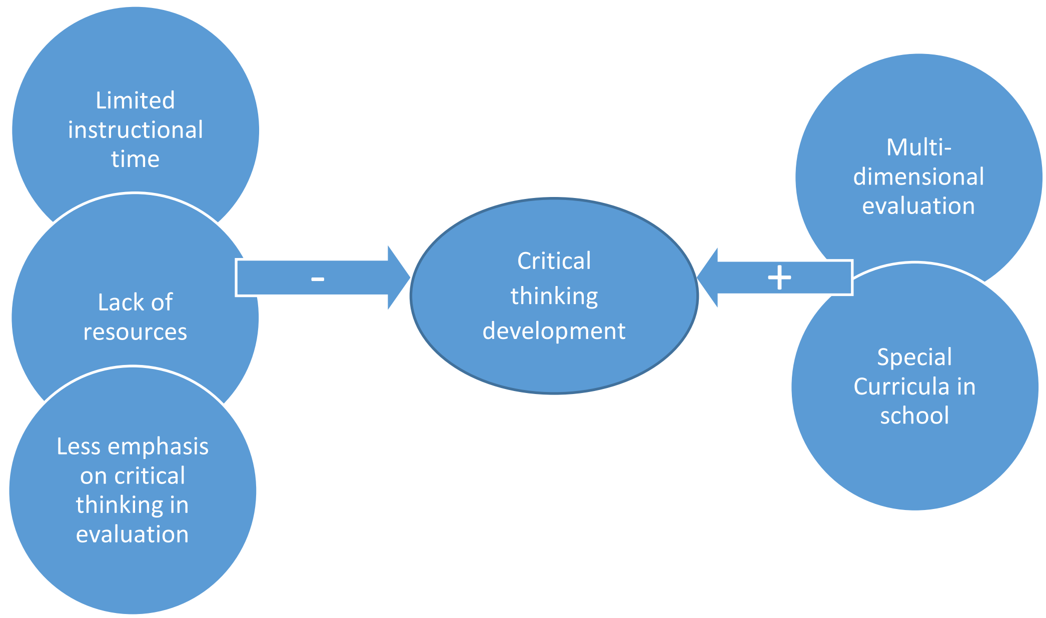

Figure 5.1 Impediments and supports to critical thinking development

5.3.4 Internal Factors Affecting Students' Critical Thinking in CLIL Mathematics Classrooms

Participants felt that teachers' general instruction and teaching methods could significantly influence students' critical thinking development. Teachers play a significant role in providing the essential abilities and traits of comprehensive critical thinking for children and need to make an effort to realize the significance of their role (Willsen & Binker, 1993). During the teaching term, teachers can create their own style and methods in order to deliver lessons to students (Louck-Horsley & Matsumoto, 1999). The classroom environment, teachers' attitudes, and teaching methods were important factors that were related to the performance of students when using English as a medium of instruction in mathematics (Mansor, 2011). In the current study, the participants also mentioned some methods to promote students' critical thinking development in their interviews. These methods appear to be consistent with the research, such as teaching through raising questions for students, problem-solving in exercises, and creating better settings. For example, Widyatiningtyas et al. (2015) stated that problem-based learning can promote students' mathematics critical thinking in both the aspects of ability and disposition. As a result, teachers should employ student-centered instruction to develop students' higher order mathematics thinking skills. Moreover, a comfortable and attractive classroom is an environment which would be able to stimulate learning (Ahrentzen & Evans, 1989). A conducive environment is always vital and effective for learning (Walberg, 1991). Though the creation of teachers' personal teaching styles, learning interest can be generated through the feelings of comfortableness in the classroom setting. Teachers can also apply educational technology to enrich mathematics teaching methods in order to create environment to support learning.

It emerged from the participants' responses that students' additional language proficiency was another significant factor that could affect their critical thinking development. First, additional language acquisition could affect students' learning attitudes toward mathematics (Truxaw, 2014), and as a result, it could also affect their mathematics learning and critical thinking development. Second, students need to gain both subject content and language skills in a CLIL environment (Marsh, 2008). Their additional language proficiency will determine how they can allocate their time in class to subject learning and additional language learning, which could then influence their critical thinking development. Moreover, students with better English language proficiency may tend to feel less language learning anxiety in CLIL learning environments. Fahim (2014) found that students with less anxiety in additional language learning tended to have higher development of critical thinking. In addition, students' additional language proficiency affects their understanding of lectures and teaching strategies that teachers use to promote their critical thinking.

It is surprising that only one participant mentioned that teachers' additional language proficiency could affect mathematical teaching and learning in CLIL. The reason may lie in that participants thought their English level was higher than their students' English language levels, especially for academic English in mathematics. Research has shown that CLIL teachers need high linguistic competency in the additional language, including language proficiency and language teaching methodology, to be qualified to teach subjects in CLIL (Papaja, 2013). Teachers without high additional language competency cannot express teaching in the target language quickly, clearly, and correctly. Therefore, teachers' additional language competency is an important factor that needs to be considered in CLIL mathematics classroom. Figure 5.2 describes internal factors that influence students' critical thinking development.

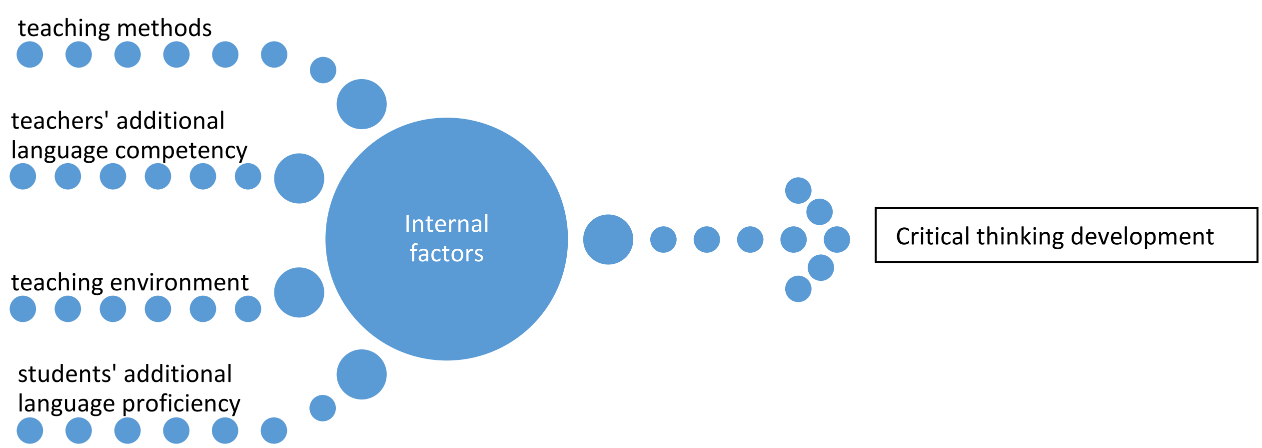

Figure 5.2 Internal factors that influence students' critical thinking development

5.3.5 CLIL

CLIL is an integration of both language and content learning (Marsh, as cited in Larsen-Freeman & Anderson, 2011), with the same emphasis on each part. However, most participants indicated that they saw themselves first and foremost as subject matter teachers. It is consistent with some of the previous research. For example, as Creese (2005) remarked, language and content teachers thought that they had separate roles: language teachers should engage in language work and subject teachers should focus on subject matter content. Even though both language and content were supposed to be developed in CLIL classrooms, that was not always the case.

In Tan's (2011) research, his findings indicated that one reason teachers in CLIL classrooms put more emphasis on content teaching was that all of them had, for the most part, only been trained in subject content teaching, which was the same case for the participants in the current study. Six participants with teaching certificates in China in this study had no theoretical knowledge and practical experience related to additional language teaching and learning. Therefore, their primary pedagogical focus in the classroom was on teaching content even though they understood the importance of language in the teaching and learning process. Moreover, because they worked within an exam-driven education system, mathematics teachers were very concerned with subject matter mastery and student achievement (Tan, 2011), which would affect their pedagogical choices during instruction. Another reason that participants believed that language was not as important as learning the subject was there was no specific evaluation related to language achievement in their CLIL classrooms. Subject teachers had the responsibility of preparing their students to achieve good grades in the subjects they taught and took little responsibility for students' additional language achievement. Therefore, curriculum and exam pressures, time constraints, and teaching responsibilities, contributed to teachers' adopting teaching practices that were time efficient, but typically with restricted opportunities for student language production. There appeared to be little effort to incorporate classroom activities that could also explicitly promote students' linguistic development and the results in the current study are consistent with what has been found in other contexts when language is expected to be learned alongside subject matter in classrooms. The focus in CLIL classrooms tends to be predominantly on content and not language (Swain, 1988).

Teachers' beliefs concerning language and subject learning exert a strong impact on how they teach, which consequently could influence what students learn in their classrooms, including both subject learning and language learning. In the absence of formal professional development on integrating content and language teaching, teachers' beliefs become a crucial factor guiding their classroom pedagogical practices (Tan, 2011). Studies across both language classrooms and subject matter classrooms demonstrate that teachers' beliefs are determinant in the planning of lessons and the teaching and learning activities that happen in the classroom (Sullivan & Woods, 2008). Teachers' beliefs may negatively affect language learning. For example, teachers with the belief that they are foremost subject teachers tend to put a low emphasis on language learning in their instruction, and instruction with a low level of language emphasis could affect mathematics learning. For example, in the interviews, participants mentioned that they would use a number of ways to support students' learning, such as translation, key word memorization, training through exercises, and so on, which was consistent with some research. Huang and Normandia (2008) noticed that approaches such as translation, simplification, or an emphasis on key words were common practices used by mathematics teachers. Less linguistically proficient students were trained to select certain mathematical operations for addressing the problem when they recognize a key word. However, these ways could be harmful for students' mathematics learning, Clement and Bernhard (2005) pointed out that word problems were often presented to help students develop mathematical reasoning skills. According to them, by having students focus on key words in isolation, teachers were simplifying the complex process of problem solving and students may indeed solve specific problems but fail to develop the desired reasoning skills. Moreover, Hancewicz (2005) claimed that whereas drills may lead to efficiency in problem solving, they do not necessarily entail deeper conceptual understanding for students. Moschkowich (2007) stated that, “instruction focusing on low level linguistic skills, such as vocabulary, neglects the more complex language skills necessary for learning and doing mathematics (p. 92).” In addition, the lack of language emphasis in CLIL mathematics classrooms reduces the opportunities for students to verbally and textually engage with the ideas presented in classes to create their own understandings, and the teacher-centered classroom where students hardly produce language might also hinder student learning (Tan, 2011). Therefore, based on the participants’ perceptions, it appears that teachers’ beliefs related to CLIL could influence students’ mathematical learning significantly.

Instruction with a low level of language emphasis can also hinder students’ additional language acquisition in CLIL. CLIL is supported by Krashen’s (1982) theory of the monitor model and comprehensible input, which argues that additional language learning happens when students engage in texts and activities that are meaningful to them and relevant to their needs, without explicitly focusing only on the linguistic forms and structures. Instruction with a low level of language emphasis could have less comprehensible input for students. One participant mentioned that teachers tended to use the first language (Chinese) to do translations for students instead of modifying their expression to suit students’ English levels in order to help them understand classroom discourse, thus entailing a lost opportunity for comprehensible input. Yet, students require even more than just comprehensible input. Swain (1996) claimed that comprehensible input and meaningful contexts were not enough. Lyster (2007) emphasized the need for learners to focus on language through form-focused instruction that includes awareness, practice tasks, and corrective feedback. Language and content teachers must plan and integrate language activities into content classrooms (Barwell, 2005). However, teachers' beliefs about CLIL may result in a low emphasis on language learning and there may be little effort to incorporate classroom activities that could explicitly promote students' linguistic development. Most content teachers have not received any professional development in additional language pedagogy and they struggle with how to teach both content and language at the same time. Some participants said they did make efforts to incorporate linguistic elements into mathematics teaching. However, these efforts were limited to mathematics terminologies and expressions and the effectiveness could not be guaranteed due to their lack of theoretical and practical knowledge about additional language teaching and learning, and there was no overall plan to systematically integrate content and language teaching. Figure 5.3 describes how teachers' beliefs about CLIL appears to affect students' critical thinking development.

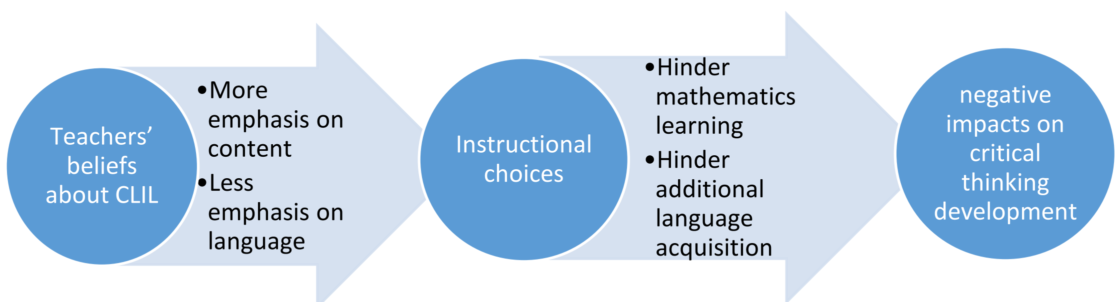

Figure 5.3 How teachers' beliefs about CLIL affect students' critical thinking development

5.3.6 Additional Language Proficiency in CLIL Mathematics Classrooms

The importance of instructional language in mathematics education is crucial since it covers aspects of teaching, learning, understanding, and communication in mathematics.

Through the use of language, mathematics becomes meaningful and students are able to communicate in the language of mathematics. The objectives of mathematics education are for students to understand mathematical concepts and possess the ability to express their understanding of these concepts (Tan, 2011). Therefore, students' language proficiency in relation to the instructional language is an influential factor that should be considered in CLIL. Figure 5.4 describes the relationship between additional language proficiency and critical thinking development.

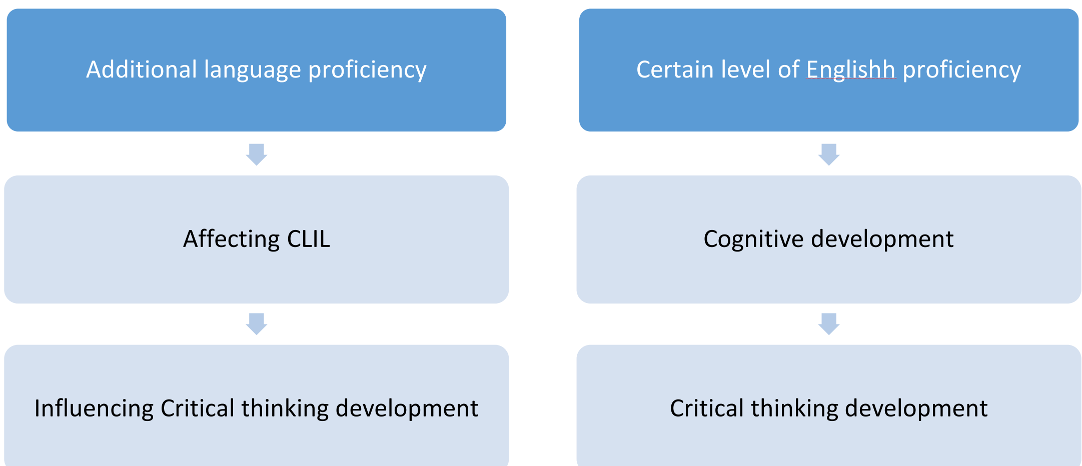

Figure 5.4 Relationship between additional language proficiency and critical thinking development

First, as the participants expressed, students' additional language proficiency has a big influence on students' learning in CLIL. Li & Shum (2008) asserted that students without adequate English proficiency were greatly hindered in learning non-English subjects, became reluctant to ask questions and express ideas, and even lost interest in the subjects. Ebad (2014) pointed out that students and instructors from linguistically diverse backgrounds, encountered high levels of challenges and obstacles during the course of classroom instruction in an English instructional environment. Students with low English language proficiency could be marginalized in CLIL, and their participation levels could be greatly reduced (Manh, 2012).

Second, the participants thought that students should reach a certain level of English language proficiency to be ready for CLIL, which was consistent with some of the literature. For successful learning of mathematics to occur, students must first master the subject’s specific discourse (Lemke, 1990). Students must attain some proficiency in English if they are to benefit from mathematics instruction in that language (Truxaw & Rojas, 2014). Cummins (2000) proposed that there was a threshold level of proficiency in a target language “which students must attain in order to maximize the cognitive, academic, and linguistic stimulation they extract from social and academic interactions with their environment” (p. 37). Bialystok (2009) claimed that cognitive advantages for bilinguals were those people who were fully bilingual and had a very high level of proficiency. It seems like it may be reasonable to require that students receiving English medium instruction in China be able to attain a certain level of bilingualism needed in order to gain the potential cognitive benefits afforded by the bilingual experience. Moreover, students’ additional language proficiency could affect their learning attitudes to that language. There are factors that play a significant role in the formation of students’ language attitudes. Galloway stated that the “use of and familiarity with the target language, stereotypes, previous experiences, and future goals” (p. 795) all play a role. Just as some participants said, students with lower levels of English language proficiency tended to have a negative learning attitude to both content and language learning since they could not understand the language and use it. All in all, it seems that language use and comprehension can impact students’ attitudes and appreciation of mathematics (NCTM, 2000). Furthermore, a student’s English language ability could be influenced negatively if that student has negative attitudes toward the target language

(Sze-yan, 2005). Therefore, a certain level of English language proficiency could facilitate students' positive learning experiences and help students from diverse linguistic backgrounds establish a positive attitude toward English and learning in English.

As to what is the exact threshold level of English language proficiency to be ready for CLIL, there was no consensus among the participants. However, most participants thought that English used in the mathematics classroom was different from English used in daily life, and students needed a moderate level of English language proficiency, between IELTS 5 to 6, to be ready for CLIL in secondary mathematics. For additional language acquisition, Cummins (1980) makes the distinction between two differing kinds of language proficiency, namely, conversational language proficiency and academic language proficiency. The IELTS levels indicated seem to point to students needing a developing level of academic language proficiency. Research from the area of mathematics teaching points to the idea that mathematical discourses are specific registers (Pimm 1987; Halliday & Martin, 1993), with their own fields, audiences and modes of communicating. It is reasonable to assume that students with moderate English language proficiency could be put in a CLIL mathematics classroom since they could cope with overall meaning in most situations and start to acquire greater levels of academic language proficiency which plays a more important role in CLIL mathematics classroom.

5.3.7 The Role of First Language in CLIL Mathematics Classrooms

In the scholarly literature, teachers appeared to have different views on the role of the first language and the instructional language. That is, some teachers have regarded it as important not to use any first language in CLIL education, whereas others have not felt that strictly about the occasional use of the first language (Marsh, 1997). Figure 5.5 describes the relationship among first language, additional language, and mathematics learning.

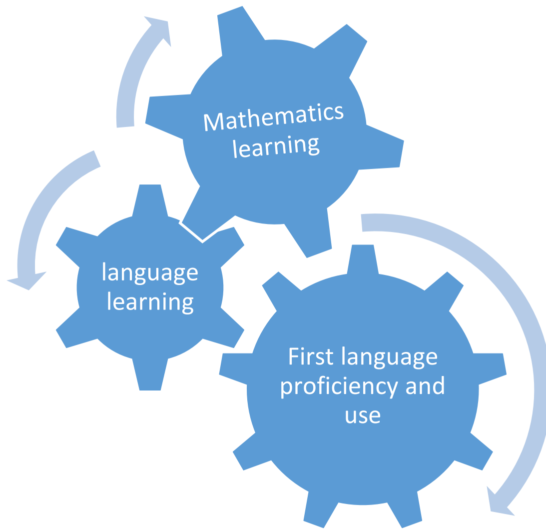

Figure 5.5 Relationship among first language, additional language and mathematics learning

In the present study, most participants interviewed thought the first language was important in supporting the learning of lower English language proficiency students' in CLIL settings and mentioned it as a way to enhance effectiveness. The first language could help students' subject learning and additional language acquisition through making input comprehensible. This is supported by some literature. For example, Cummins (2000) believed that in the process of learning one language, a child acquires a set of skills and implicit metalinguistic knowledge that can be drawn upon when working in another language. He called these skills and knowledge the Common Underlying Proficiency (CUP). CUP provides the base for the development of both the first language and the additional language. Any expansion of CUP that takes place in one language will have a beneficial effect on the other language. Students already have knowledge and skills in their first language. It is important for teachers to use them for students' additional language acquisition. As Cummins (2000) states: "Conceptual knowledge developed in one language helps to make input in the other language comprehensible" (p. 39). Providing opportunities to reason in one's first language can support sense making (Truxaw & Rojas, 2014). For example, if students already understand the concept of perimeter in their first language, once the teacher tell students what perimeter means in their first language in during a class, all the students have to do is acquire the label for the term in English, and it helps them understand the discourse around that word, such as how to solve for the perimeter of a graph. Students can thus understand lectures easier and faster. Moreover, Launio (2015) indicated that success in mathematics was influenced by the medium of instruction, and he believed that students taught in bilingual classrooms could learn better than in pure English. Because students could hardly understand simple pure English as a medium of instruction in mathematics lessons, the first language should be used as a supplement in CLIL to enhance students' understanding of content.

However, one participant expressed the opinion that if teachers could alter their expressions to suit students' English level to help them understand the teaching activities taking place in class, first language use would be not necessary. This position is consistent with Long's (1996) theory related to modified input. Modified input occurs when proficient language speakers change or adapt their speech and language to communicate with less proficient speakers. Additional language learners benefit from the efforts of highly proficient speakers and fluent bilinguals to modify their speech to help them understand. Moreover, too much use of the first language in CLIL education may lead to a situation where students do not even attempt to understand challenging additional language input, as they take it for granted that the same will be said also in their first language (Roiha, 2014).

It is too challenging to ask that no first language be used in CLIL mathematics classrooms if teachers are not from English speaking backgrounds and students' additional language proficiency is relatively low. Instead, teachers could employ a systematic and reasonable way to use the first language, and first language use can be an effective method for supporting the students' participation in CLIL education (Roiha, 2014). Because most CLIL mathematics teachers lack professional development connected to how to properly integrate content and language together, recent research has shown that co-teaching, teaching by both language teachers and content teachers, can be an effective method (Rytivaara, 2012). However, teacher collaboration between language teachers and content teachers can be hindered by teachers' negative attitudes towards collaboration or their differing views, roles and positions in schools (Arkoudis,2006). Thus, steps have to be taken to facilitate effective collaboration between language and content teachers.

5.3.8 Mathematics Language

The participants emphasized that mathematics has its own language. First, English used in the mathematics classroom was different from English used in daily life. This idea is consistent with some of the literature. For example, research from the area of mathematics teaching points to the idea that mathematical discourses are specific registers (Pimm 1987; Halliday & Martin, 1993), with their own fields, audiences and modes of communicating. As mentioned before, for additional language acquisition, Cummins (1980) makes the distinction between two differing kinds of language proficiency. BICS refers to basic interpersonal communication skills, which are the surface skills of listening and speaking that are typically acquired quickly by many students. It is called conversational language. CALP refers to cognitive academic language proficiency, which is the basis for a student's ability to cope with the academic demands placed upon her in the various subjects. It is related to academic language. It is important to note that it should not be assumed that non-native speakers who have attained a high degree of fluency and accuracy in everyday spoken English have the corresponding academic language proficiency.

Second, some participants found that some words used in mathematics situations had different meanings attached to them when used in other situations. Specifically, the mathematics register can be defined as the meanings belonging to the natural language used in mathematics, including vocabulary and arguments (Cuevas, 1984). Halliday (1975) has suggested that a mathematics register has some particular components. The first one is natural language words reinterpreted in the context of mathematics, such as set, point, field, even, and prime. These language words often make students confused and result in their misunderstandings of sentences, which was also noticed by some of the participants. It is important that students be able to distinguish those words in mathematics from those words in daily life.

Language is a resource for meaning-making and participation in various communities of practice (Wenger, 1998). For students, they first need a certain level of additional language proficiency to be involved in the CLIL mathematics classroom. After that, for teachers, they need to design activities and use teaching methods to promote students' mathematics language in English purposefully. Figure 5.6 below describes mathematics language in CLIL mathematics classroom.

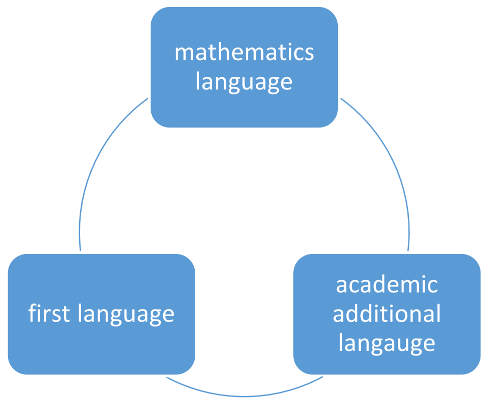

Figure 5.6 Mathematics language in CLIL mathematics classroom

5.3.9 Disadvantages and Advantages of CLIL

Much research has shown that using English as a medium of instruction for students from non-English speaking backgrounds has a significant influence on learning in both negative and positive ways (Ebad, 2014; Launio, 2015; Li & Shum, 2007; Manh, 2012; Mufanechiya & Mufanechiya, 2010; Muthanna & Miao, 2015; Yip & Tsang, 2006).

On the one hand, slowing down the schedule, lowering teaching quality, increasing difficulty in instruction, decreasing learning motivation towards mathematics, degrading academic achievement, hindering students' subject learning were mentioned by the participants as the disadvantages of CLIL, which were consonant with some of the literature. For example, Ebad (2014) pointed out that students and instructors who were non-native English speakers encountered high levels of challenges and obstacles during the course of classroom instruction in an English instructional environment.

It was pointed out by the participants that CLIL could slow down the instructional schedule. There are challenges involved in switching between languages; for example, the response time for arithmetic operations may be longer when using an additional language

(Moshchkovich, 2012). Academic language is much more challenging than conversational language to be understood; it is more abstract, more contextualized, more specific, and more culturally determined (Truxaw & Rojas, 2014). Working to understand even basic academic instructions in an additional language is challenging and exhausting. Students need more time to translate from the additional language into the first language and to understand lectures. In addition, teaching quality and students' learning interests and attitudes could be affected negatively by CLIL. Manh (2012) pointed out that the use of English as the medium of instruction had left the majority of the children marginalized and teachers confused and students' participation levels were greatly reduced. Li and Shum (2008) asserted that students without enough English proficiency were greatly hindered in learning non-English subjects, became reluctant to ask questions and express ideas, and many even lose interest in the subjects. Language use and comprehension can affect students' attitudes and appreciation of mathematics (NCTM, 2000). Asking and answering meaningful questions in an additional language is difficult; one may choose not to publicly participate when learning in an additional language (Truxaw & Rojas, 2014). Swain (1996) indicated that students in CLIL classes speak relatively little and hardly need to give extended answers. Tan (2011) found the lack of students' oral participation in the observed CLIL classrooms.

It was also found in the participant data the opinion that CLIL may have the potential to negatively affect students' academic achievements. In one study, because of CLIL, students' academic performances in secondary mathematics dropped since students were able understand the teaching and learning better in their first language as compared to English (Ahmad, 2012). It seems that students' academic performance may be affected by their additional language proficiency. Some participants thought that students' additional language proficiency could negatively influence their learning in the classroom and as a result, their academic achievements. Supporting the participant opinions, as older study by Cossio (1978) found high positive correlations between mathematics achievement and additional language ability. One reason was because the students' additional language proficiency could affect their mathematics learning process and as a result, their academic knowledge acquisition. Another important reason was the role played by language in the assessment of mathematics achievement. Garder (1985) argued that the use of English as the language of the text is one reason for the low achievement scores of students from linguistically diverse background. Meeker (1973) found that if tests were translated, students tended to do better on the first language version than on the English version. As one participant mentioned, if teachers translate the international mathematical contests into a Chinese version, far more students would be able to gain an award. Throndike (1912) noted, "Our measurement of ability in arithmetic actually is a measurement of two different things: sheer mathematical insight and knowledge, on the one hand; and acquaintance with language, on the other" (p. 292). Pretorius (2000) affirmed the need for proficiency in the target language in order for learners being taught in English to improve their academic performance. Sometimes learners who are taught in an additional language do not achieve academic excellence, not because they are incompetent, but because of language barriers (Adler, 2001; Nasir, 2007).

Some participants also thought that CLIL could hinder students' mathematics learning. The objectives of mathematics education are for students to understand mathematical concepts and possess the ability to express their understanding of these concepts (Tan, 2011). Being literate in mathematics means not only knowing facts and figures but also being able to participate in discussions concerning their choices when questioned (Solomon, 2009). This is not easy to do, even in the students' first language. The mastery of the language of mathematics becomes more complicated when the students are learning these subjects in their additional language (Crandall, 1987). CLIL may be difficult for additional language learners because these students have to learn words and language as applied to concepts unfamiliar in their daily lives. Cummins (1980) has noted the difference between this cognitive academic language proficiency and the language used in social situations. According to Fillmore (1982), the language of textbooks and instruction "frequently calls for a high degree of familiarity with words, grammatical patterns, and styles of presentation and arguments that are wholly alien to ordinary informal talk" (p. 6). Some of the academic language used in materials and discussions in the mathematics class may be especially difficult for additional language learners to follow. Academic language is much more challenging than conversational language to be understood; it is more abstract, more contextualized, more specific, and more culturally determined (Truxaw & Rojas, 2014). Working to understand even basic academic instructions in an additional language is challenging and exhausting, not to mention that students have to face in their struggle to simultaneously master academic concepts while improving their linguistic skills (Bruna & Gomez, 2009). Moreover, many subject teachers in CLIL classrooms do not have any specific professional development in language education (Barwell, 2005). Little specific support solves how teachers can integrate content learning and language learning. Fortune et al. (2008) found little attention is paid to the kinds of pedagogy required for teaching in these classrooms. In addition, Huang's (2009) research showed that students were worried about a potential loss of academic knowledge resulting from a slower speed of course delivery while they had an increased confidence or interest in English learning in CLIL. Many teachers have complained that they have to reduce or simplify curricular content to accommodate English medium instruction because their students lack the academic language competence to understand complex topics and engage in higher order thinking in English (Pi, 2004), which was also expressed by the participants in the present study. The worry is that students may have had only a superficial grasp of academic content (Yeh, 2014). Figure 5.7 below describes the main disadvantages of CLIL in CLIL mathematics classroom.

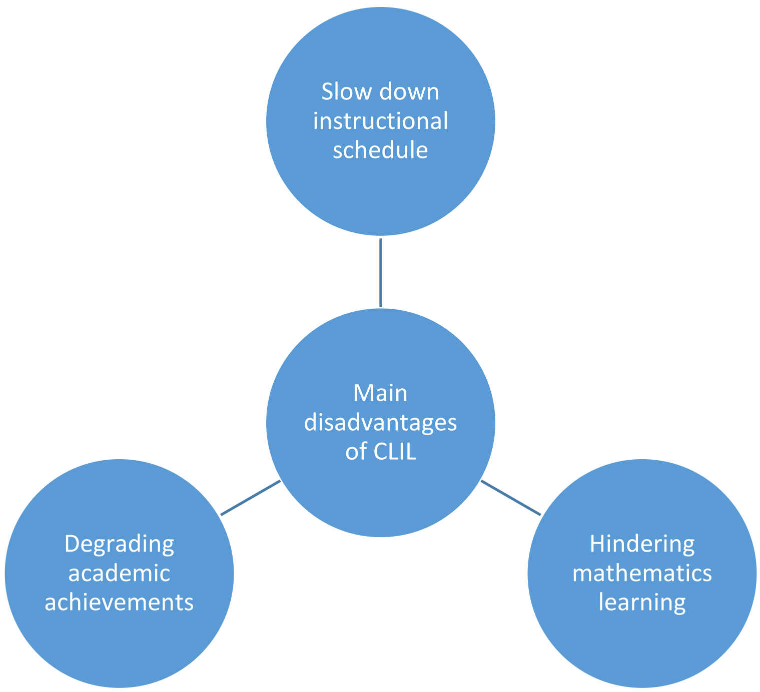

Figure 5.7 Main disadvantages of CLIL in CLIL mathematics classroom

On the other hand, some advantages of CLIL, such as stimulating learning motivation, advancing additional language acquisition, and facilitating mathematics learning, were expressed by the participants.

Participants thought that CLIL could stimulate students' learning motivation. Motivation can be conceptualized as consisting of instrumental motivation (for immediate or practical goals) and integrative motivation (for personal growth and cultural enrichment) (Gardner & Lambert, 1972). Participants' data showed that students could be motivated in CLIL since they realized it can help to enhance their additional language skills, academic performance, and future development. Thus, students have both instrumental motivation and integrative motivation to learn in CLIL. Moreover, CLIL further helps to foster positive attitudes towards language learning (Bebenroth & Redfield, 2004) and then can raise learners' motivation in both language and non-language subjects. Students are highly motivated to learn the target language possibly due to the fact that the language is used in real life settings (Infant et al, 2009). In addition, some participants expressed that students with good English proficiency tended to have higher interest in learning mathematics and this point is supported by some of research. For example, Prochazkoza (2013) claimed that CLIL could change the attitudes of many students towards mathematics positively. Tejkalova (2009) has also confirmed that CLIL has generally been viewed as motivating and challenging by mathematics learners. Nixon (as cited in Prochazkoza, 2013) has claimed that teaching subjects through an additional language could stimulate learning interest through building students' confidence, extending their knowledge, and engaging their curiosity.

Participants generally expressed the same opinion that CLIL could help by enhancing students' additional language proficiency. CLIL integrates language learning into content learning and provides a setting for students to learn language in activities that are relevant to their needs instead of focusing only on linguistic forms and structures. Moreover, CLIL can increase students' exposure to English, comprehensible input in English, and interaction through English. All these are beneficial for students' additional language acquisition. In addition, most participants mentioned that while students could gain conversational language, they could also acquire more mathematics language in English in the CLIL classroom since the language that is mostly used and emphasized in CLIL mathematics classrooms is mathematics language in English.

Some of the participants felt that CLIL could help mathematical critical thinking development since it could foster students' habits of raising questions and questioning. Students tended to question more in order to understand the lectures more thoroughly. Moreover, CLIL seemed to diversify traditional instruction and as a result, facilitate mathematical learning. Participants also mentioned that CLIL could vary their teaching methods. Learning mathematics in an additional language provides students with a different perspective on the content area; different methods necessary for instruction through an additional language can stimulate a more active approach and deeper understanding (Prochazkova, 2013). Hoffmannova (as cited in Prochazkova, 2013) further suggested that by employing diverse approaches, CLIL provided a desirable environment that could address various learning-type students. Figure 5.8 below describes the main advantages of CLIL in CLIL mathematics classroom.

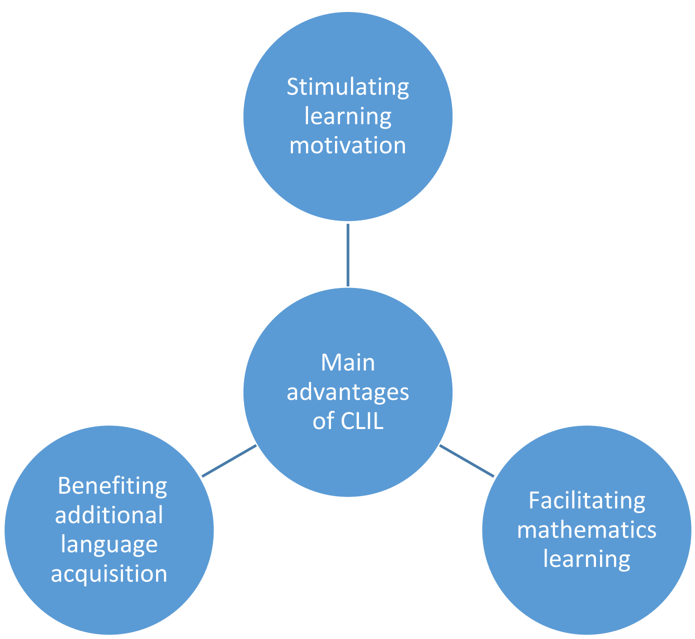

Figure 5.8 Main advantages of CLIL in CLIL mathematics classroom

5.3.10 CLIL and Critical Thinking

The participants felt that there was a relationship between CLIL and critical thinking, involving both positive and negative effects. Research has shown that students' ability to think critically is related to many things, including learning experiences, the growth of self-control and self-awareness, linguistic and reading abilities, and subject knowledge (De Boo, 1999). CLIL may affect the development of students' mathematical critical thinking through influencing their learning experiences, changing the language of instruction, and impacting their academic learning. Figure 5.9 describes how CLIL affects students' mathematical critical thinking development in positive and negative ways.

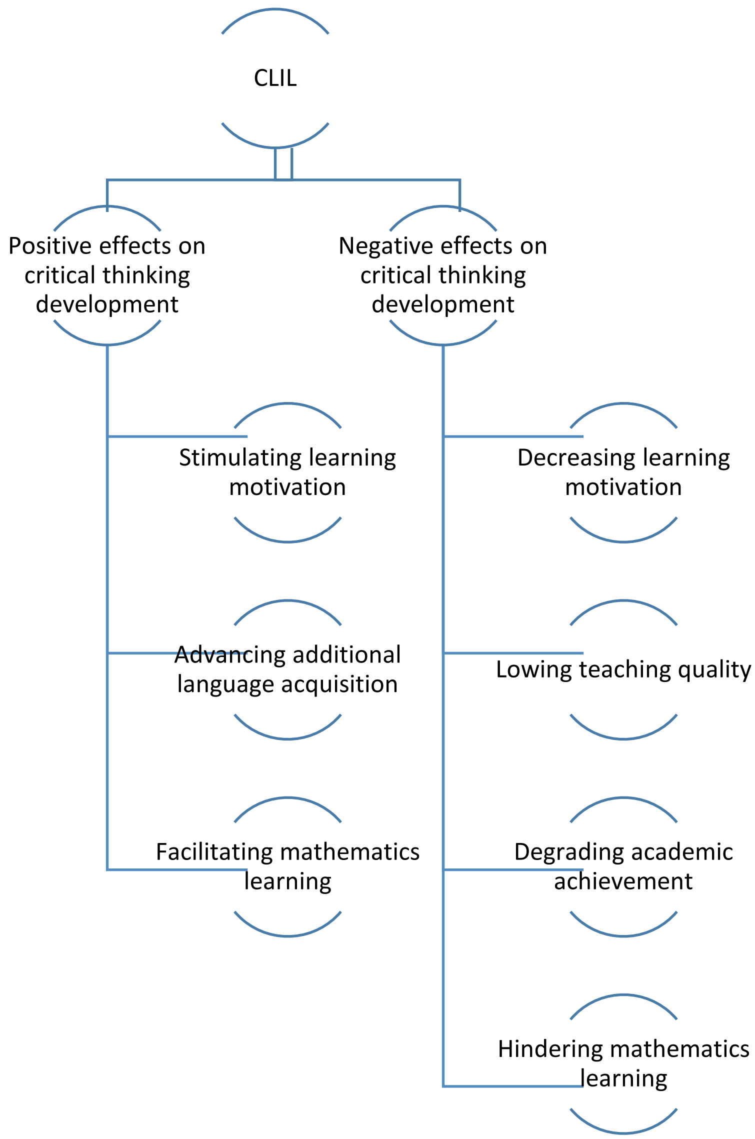

Figure 5.9 CLIL and critical thinking

On one hand, CLIL courses appear to be a good opportunity for schools to implement effective, efficient, active ways of learning, aiming for the development of both critical and creative thinking skills (Hanesova, 2014). CLIL could promote mathematical critical thinking development through developing its components. Participants pointed out that CLIL could foster students' questioning habit, which could help develop critical thinking skills. Questions stimulate the development of divergent thinking and evaluation skills, various communicative structures and productive questions are ones of the decisive factors contributing to higher cognitive skills (Gondova, as cited in Hanesova, 2014). Moreover, cognitive skills are at the very core of critical thinking (Facione, 2004). CLIL provides a desirable learning environment where learners can get a chance to use their cognitive skills and to construct their own knowledge (Hanesova, 2014). Students are intellectually challenged to transform information, to solve problems, to discover meanings. Learners maximize the use of their thinking skills for meaning-making, such as analyzing, differentiating, synthesizing, and evaluating (Hanesova, 2014), and as a result, get a crucial amount of critical thinking training since these thinking skills are an important component of mathematical critical thinking. In addition, students can gain benefits, such as higher order thinking skills, when adopting an additional language to learn mathematics in classrooms (Truxaw, 2014; Zahner & Moschkovich, 2011). Higher thinking skills are stimulated in the instruction of additional languages or in the change of language of instruction since language spontaneously employs learning activities associated with analysis, synthesis, and evaluation levels (Prochazkova, 2013).

Learning mathematics in CLIL provides learners with a different perspective on the content area and the different methods necessary and available in CLIL can stimulate a more active approach and deeper understanding (Prochazkova, 2013). In the current study, participants expressed how they used a variety of different teaching methods to help critical thinking development. Critical thinking development is able to be promoted systematically with some teaching methods in CLIL. CLIL normally contains situations and tasks with some kind of cognitive challenge in which the active involvement of students is necessary; therefore, learners have to be active and to think more about the content (Hanesova, 2014). In this sense, students can achieve greater development in their critical thinking skills.

On the other hand, the participants pointed out that CLIL could hinder students' critical thinking in the mathematics classroom through decreasing classroom participation and interaction, lowing students' learning interest, and degrading the quality and effectiveness of instruction. In CLIL, there were challenges involved in switching between languages, as mentioned before. For example, response time for arithmetic operations may be longer when using an additional language (Moshchkovich, 2012). It was mentioned by participants that the time for critical thinking development relatively decreases because of CLIL and some of them had to simplify their teaching approaches. As such, students may have had only a superficial grasp of academic content because of a lack of time and simplified teaching (Yeh, 2014), and therefore may have lost a deeper understanding of the academic knowledge and opportunities to develop their higher order thinking skills. Moreover, CLIL has a significant impact on students with low levels of English language proficiency, which was commonly agreed among participants and supported by much research. The process of additional language acquisition could negatively affect students' learning attitudes toward mathematics (Truxaw, 2014), and as a result, their mathematics learning and critical thinking development. Shum (2008) asserted that students without inadequate English language proficiency were greatly hindered in learning non-English subjects, became reluctant to ask questions and express ideas, and many even lose interest in the subjects being studied. As a result, as the participants indicated, CLIL could hinder the process of students' critical thinking development.

5.4 Applications of the Research

The findings of the current study could provide offshore Canadian secondary schools with information on how CLIL might affect students' mathematical critical thinking development. Schools' physical environment, curriculum and evaluation system, students' additional language proficiency, and teachers' additional language and beliefs towards CLIL are all some of the factors that need to be considered. By understanding those factors that could influence students' critical thinking development in mathematics, schools can develop a better CLIL program to facilitate students' critical thinking development. CLIL is becoming more and more common in China, not only in mathematics, but also in other subjects. This study provides information and possible insights into how CLIL could affect other subjects' learning.

Although this study focused on teaching and learning in Canadian offshore schools in China, it could have possible insights for CLIL in mathematics in other schools, such as public schools in China, China-America schools, China-Australia schools. Additionally, the approach in the current study could be applied and adapted to different learning stage groups, attending to students in CLIL programs of all learning stage from elementary school to university.

5.5 Implications for Practice and Recommendations

Considering the findings of the study, there are many implications for practice and some recommendations. First of all, high-quality, sustained professional development should be provided by schools to support CLIL mathematics teachers. Most CLIL teachers in China only experience teacher development opportunities in their subject areas. They need additional supports in language teaching and CLIL teaching, including methodology and pedagogy about how to integrate content and language together in their classrooms. Mathematics CLIL teachers can be encouraged to learn and experiment with student-centered pedagogies and to consider alternative forms of assessment that promote the development of mathematics critical thinking and additional language acquisition in CLIL classrooms. As Bonk and Cunningham (1998) remarked, one of the fundamental issues in teaching and learning relates to the implementation of learner-centered approaches, and the key idea behind learner-centered teaching was that learners could learn best when they were involved in the topic and motivated to seek out new knowledge and skills because they needed them in order to solve the problem at hand. Moreover, teachers also need support related to the nature of CLIL, since their misunderstanding of the nature of CLIL could affect their pedagogical choices in instruction.

Students can be differentiated before being placed in CLIL education since there appears to be a threshold level of English proficiency for CLIL, as indicated by the participants. Students with lower levels of English language proficiency perhaps should not be placed in an additional language environment which is predominantly English, particularly if there are not extensive supports. Chamot (1982) suggested that when a student enters an additional language program, a diagnosis should be made of his or her proficiency in the language functions required by the subject matter. After that, teachers could make an effort to enable more effective and suitable teaching for pupils.

Schools and teachers need to develop a CLIL mathematics curriculum that includes emphasis on both content and language teaching. With this kind of curriculum, teachers could receive guidance about what and how they should teach in CLIL.

Schools can also seek to develop a more comprehensive assessment of student outcomes in CLIL classrooms. The evaluation system could be both an impediment or a support for critical thinking development. The traditional evaluation system in China may have the unintended impact of weakening the advantages of CLIL. A specific and special assessment is needed for CLIL.

Governments should consider investing further money and resources into CLIL teacher development, instructional facilities, and learning materials creation. Language support may also be called for. In particular, teachers from linguistically diverse backgrounds may not have the oral competence to teach other subjects bilingually (Pi, 2004). Governments could set diagnostic tests to evaluate CLIL teachers' English proficiency and issue certificates to guarantee teachers' additional language proficiency while providing targeted language support to foster the language development of teachers. In addition to language, this certification could also focus on supporting the development of instructional strategies that work in CLIL classrooms. In particular, CLIL teachers should be familiar with theories of additional language acquisition, such as Krashen (1982) and Long (1996). This understanding will support CLIL teachers using instructional strategies that provide learners with the comprehensible input that supports both language and content acquisition. For example, teachers could modify their instructional language, use more key visuals in class, provide vocabulary definitions in the form of word walls, incorporate structured pair and group work, and other constructivist instructional strategies. Moreover, appropriate instructional and learning materials for English medium instruction are in dire shortage (Liu, 2002), and supports, such as professional development and funding, could be put into place to develop these needed materials.

5.6 Limitations and Assumptions

The study was delimited to include consenting teachers with experience in Canadian offshore schools who were known to the researcher. Moreover, this study was limited to teachers who had at least three years' current or recent teaching experience in CLIL environments in Canadian offshore schools.

The researcher acknowledges that there will always be limitations and assumptions made within a study and there will always be uncontrollable factors. The first issue was the assumption that volunteers for interviews would try to arrange time for the interviews. However, some potential participants were so busy and they had no time to do an interview which would take one to two hours, and thus could not take part. Furthermore, data collection was done over the two months after participants gave their consent to participate in the semi-structured interviews, and some potential participants were unable to participate in the study since they could not find any time after two months. In the end, all of the participants current or recent teachers in the same organization of Canadian offshore schools. Another issue was the assumption that participants would provide enough information in questionnaires and interviews. However, sometimes the information participants shared on the questionnaires was not very substantive, and some of the participants did not give enough information during the interviews because of time limitations. However, these issues were solved because some participants were willing to take part in a further session to continue exploring the topic. In the end, three of the participants finished the further interview sessions.

As a result of these limitations, the study findings cannot be generalized beyond the participants experiences and the perceptions uncovered are limited to what has occurred with a small group in the same location. However, because of the qualitative nature of the study, generalizations were never the goal (Gay, Mills, & Airasian, 2012). In the future it would be interesting to gain insight on the opinions and experiences of teachers at other Canadian offshore secondary schools.

As the participants were known to the researcher, and it was assumed that the participants involved in this study did not exaggerate or omit any information or provide untrue information to please the researcher, it was assumed they were completely honest in their answers.

As the researcher was a former teacher in a Canadian offshore school, it is quite possible the study (questions, findings, methods, results) were influenced by a personal bias. However, it is important to note the researcher attempted to be objective and unbiased as possible in her actions. The researcher strove to bracket her own bias during the data analysis (Creswell, 1998). Furthermore, the researcher is a positive supporter of CLIL. This may also have altered her viewpoints when conducting the study.

Certain aspects of the study may have influenced participants to become involved, such as the relationship between the researcher and participants, the specific topic of the study, qualifying factors, time taken to participate the study. Due to the small amount of participants, it is unknown what the opinion was of all teachers in Canadian offshore schools as only teachers from the same school took part. All conclusions were found based only on the findings of the information given from the participants.

5.7 Recommendations for Future Studies

There were only seven participants in this study and all of them were from the same organization of Canadian offshore schools. In a future study, more research could be completed on this topic with more participants in different Canadian offshore schools and quantitative data could be collected to support the qualitative findings of this study. Moreover, in this study, there was only one participant who was a native English speaker. More data collected from native English speaking participants could be collected for future studies. In addition, a future research about students' perceptions of CLIL is needed to contrast with teachers' perceptions.

5.8 Conclusion

This research addressed an overlooked area in education: the impacts of CLIL on mathematical critical thinking development. According to the participants, mathematical critical thinking was related to applying prior knowledge, logical thinking, reflective thinking, and analyzing problems dialectically. In CLIL, teachers tended to see themselves first and foremost as subject content teachers and put more emphasis on content teaching instead of putting the same emphasis on content learning and language learning. According to previous research (Hanesova, 2014), CLIL is a good way to develop students' critical thinking. However, in practice, there are many factors which need to be considered in CLIL, and as a result, CLIL could affect students' critical thinking development both positively and negatively.

As the globalization of education continues around the world, CLIL is becoming more and more popular in China, including Sino-Canadian schools, Sino-American schools, and Chinese public schools. Studies such as this one will become more important so as to gain insight into the perceptions of CLIL teachers. The findings of this study, though not suitable for generalization, may still offer some insight into how to improve CLIL programs. The information in this study is beneficial to the growth of this field of learning and education for students, educators, and schools.

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Appendices

Appendix A: Email Invitation Letter

[Email Invitation Letter]

Dear [insert potential participant's name here],

My name is Tian Li. I am a graduate student in the Faculty of Education on UBC's Okanagan campus. My graduate supervisor is Scott Douglas (scott.douglas@ubc.ca).

I would like to invite you to participate in my research project. The project includes an email questionnaire and an online interview. The purpose of the study is to explore teachers' perceptions of the development of mathematical critical thinking skills in content and language integrated learning classrooms for students from non-native English speaking backgrounds studying secondary mathematics in China.

The email questionnaire is attached to this email. You will also find an attachment with more information about Informed Consent. Please read the information on informed consent. After you have read the information on informed consent, please choose "yes" for the first question on the questionnaire if you want to take part in this study.

The questionnaire should only take approximately **20 minutes** of your time. If you agree to an online interview, the interview will take approximately **30 minutes** of your time. Your participation will help me have a greater understanding of the relationship between content and language integrated learning and Chinese students' mathematical critical thinking. A response with completed questionnaire will be appreciated within 15 days after you have received this email.

Thank you for considering taking part in this study. If you have any questions, please do not hesitate to be in contact.

Yours truly,

Tian Li

[Information about Informed Consent and the Questionnaire is Attached]

Tian Li
Graduate Student
Faculty of Education, Okanagan Campus
1137 Alumni Avenue, Kelowna, BC V1V 1V7

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Appendix B: Consent Form

<u>Information about Consent</u>

What is the title of this study?

Critical thinking in the content and language integrated classroom: Perceptions of secondary mathematics teachers in overseas Canadian curriculum contexts

Who is doing this study?
Tian Li, MA candidate, Faculty of Education, University of British Columbia's Okanagan campus. As a graduate student, Tian Li is the co-investigator of this study.
[email address]
(250) 899-6502

Who is Tian Li's graduate supervisor?
Scott Roy Douglas, PhD, Faculty of Education, University of British Columbia's Okanagan campus. As the graduate supervisor, Scott Roy Douglas is the principal investigator.
scott.douglas@ubc.ca
(250) 807-9277

Who is funding this study?
Currently there is no funding for this study.

Why take part in this study?
Your voice is very important to the study. The objective of the study is to understand teachers' perceptions of the relationship between content and language integrated learning and students' mathematical critical thinking in secondary school contexts. In turn, teachers will gain a better understanding of their teaching and the investigators will learn more about mathematical critical thinking and content and language integrated learning in China. This is an entirely voluntary opportunity. Whether or not you agree to participate, it will have no effect on your teaching in your schools.

What happens if you say "yes"?
When you participate in this study, you will complete a **20 minute** questionnaire about who you are and your experiences and perceptions. Please complete all of the questions in the questionnaire. If you agree by providing your email address in the questionnaire , you may be contacted for a follow up online interview about your experiences. A follow up online interview would take approximately **30 minutes** of your time. This online interview would take place via Skype at a mutually convenient time. The online interview will be audio recorded, and the co-investigator will also take notes. If you are willing to participate in a further online interview, please provide your e-mail address at the end of the questionnaire. All names and email addresses will be kept confidential and will only be used for this study. If you take part in the online interview part of this research, before you participate in the online interview you will have another opportunity to review this consent form to remind you about informed consent. You may

choose to withdraw at any time. Information gathered in the questionnaire and the online interview will be used to develop the co-investigator's master's thesis.

How will you know the results of the study?
If you would like to know the results of the study please contact the researchers or leave your email address at the end of the questionnaire. As a result, we will contact you by email with the results. The findings may be reported in presentations and journals developed around the co-investigator's master's thesis; it will also be a public document available online through UBC's *Circle.*

What are the risks of participating in the study?
This is considered a "low risk" study meaning there are no risks greater than what you would experience in your daily life when participating in this study. Nothing in this study will harm you or affect you negatively. You can decline to participate by not completing the questionnaire. Once you start you may quit by not sending your responses with no adverse effects.

What are the benefits of participating in the study?
The information you provide may assist in understanding mathematical critical thinking and content and language integrated learning further. You will be able to reflect on your teaching experience as a mathematics teacher.

How will your identity be protected?
The email questionnaire does not ask for personal identifiers or any information that may be used to identify you. Data gathered through email questionnaire will be downloaded to a password-protected computer. A backup of the digital files will be kept on a password protected portable hard drive. The drive will be kept in a locked cabinet on UBC's Okanagan campus. After the completed questionnaires are downloaded, emails including completed questionnaires will be deleted from the researcher's inbox.

All of the collected data will be kept in a locked cabinet in the office of the Principal Investigator at UBC's Okanagan campus for five years, after which it will be destroyed. Only the Principal and Co-Investigator will have access to this data. All original data and associated research material must be stored securely for at least five years following publication.

Who can you contact if you have any questions about the study?
Please contact one of the researchers if you have any questions. Their names, phone numbers, and email addresses are provided above.

Who can you contact if you have any complaints or concerns about the study?
If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the Research Participant Complaint Line in the UBC Office of Research Services at 1-877-822-8598 or the UBC Okanagan Research Services Office at 250-807-8832. It is also possible to contact the Research Participant Complaint Line by email (RSIL@ors.ubc.ca).

Participant Consent for the Questionnaire.

Taking part in this study is up to you and you have the right to refuse to participate. If you decide to take part, you may choose to pull out of the study at any time by not completing the questionnaire, you do not have to give a reason for opting out. If you complete the questionnaire, you do not have to take part in the online interview. If you agree to take part in the online interview, the online interview will be recorded and notes will be taken. By reading this information and sending back the completed questionnaire with the answer to the first question "yes", you agree to participate in this study. If you take part in the online interview, you agree to the online interview being recorded. Your signature is not required, and you will not be required to submit a copy of this by email. If the questionnaire is submitted, it will be assumed that consent has been given. You may print out a copy of this message to keep for your records.

Appendix C: Email Questionnaire

Email questionnaire

Critical thinking in the content and language integrated classroom: Perceptions of secondary mathematics teachers in overseas Canadian curriculum contexts

Please type your answers directly into this document. When you are finished, please send this document to Tian Li at [email address].

Section 1: Informed Consent

I have read the information on informed consent attached to the invitation email, and I agree to take part in this study (check one)

☐ YES
☐ NO

Section 2: Demographic Questions

Please answer these questions to the best of your knowledge:

1. How old are you?

2. What is your country of origin?

3. What is your first language?

4. Where did you get your teaching certificate?

5. How many years have you been teaching mathematics in content and language integrated learning classroom?

6. What grades have you taught?

Section 3: Short Answer Questions

(Minimum 25 word answer. Please use complete sentences)

1. What is mathematical critical thinking?

2. What role does mathematical critical thinking play in your classroom and in your school?

3. How is content and language integrated learning different from traditional learning in mathematics classrooms?

4. How has content and language integrated learning affected your teaching?

5. Describe how content and language integrated learning has positive or negative influences on students' academic content learning,

6. How does content and language integrated learning effect students' development of mathematical critical thinking?

7. Describe a time you felt you were really successful at promoting students' mathematical critical thinking in a content and language integrated classroom.

8. Do you think different learning topics in mathematics (algebra, functions, geometry and so on) influence the development of mathematical critical thinking in content and language integrated learning classrooms or not? Give specific examples.

9. Is there anything else you would like to share?

Section 4: E-mail for an Online Interview

Please provide your email below if you would like to volunteer to participate further in the online interview portion of the study.

E-mail address (optional):

Thank you very much for participating in our study. It is much appreciated!

Appendix D: Online interview questions

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Critical thinking in the content and language integrated classroom: Perceptions of secondary mathematics teachers in overseas Canadian curriculum contexts

Semi-Structured Interview Questions:

1. What is critical thinking and what is mathematical critical thinking?
2. What role does mathematical critical thinking play in your classroom and in your school?
3. How is content and language integrated learning different from traditional learning in mathematics classrooms?
4. Do you have any difficulty in using content and language integrated learning in your classroom? Explain.
5. How has content and language integrated learning affected additional language acquisition in your classroom?
6. How has content and language integrated learning affected teachers' teaching and students' mathematics learning, for example, students' achievements, motivations, and understandings and so on.
7. How has content and language integrated learning influenced the development of students' critical thinking?
8. Describe a time you felt you were really successful at promoting students' mathematical critical thinking in content and language integrated classroom.
9. Do you think different learning topics in mathematics (algebra, functions, geometry and so on) have influence on the development of mathematical critical thinking in content and language integrated learning classrooms or not? Give specific examples.
10. Is there anything else you would like to share?

Appendix E: Certificate of approval

The University of British Columbia Okanagan
Research Services
Behavioural Research Ethics Board
3333 University Way
Kelowna, BC V1V 1V7 Phone: 250-807-8832
Fax: 250-807-8438

CERTIFICATE OF APPROVAL - MINIMAL RISK

PRINCIPAL INVESTIGATOR:	INSTITUTION / DEPARTMENT:	UBC BREB NUMBER:
Scott Douglas	UBC/UBCO Education, Faculty of/UBCO Education, Department of	H16-03003

INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT:

Institution	Site
UBC	Okanagan

CO-INVESTIGATOR(S):
Tian Li

SPONSORING AGENCIES:
N/A

PROJECT TITLE:
Critical thinking in the content and language integrated classroom: Perceptions of secondary math teachers in overseas Canadian curriculum contexts

CERTIFICATE EXPIRY DATE: December 20, 2017

DOCUMENTS INCLUDED IN THIS APPROVAL: | **DATE APPROVED:** **December 20, 2016**

Document Name	Version	Date
Protocol:		
Research Proposal	2	December 14, 2016
Consent Forms:		
Information on Informed Consent	2	December 14, 2016
Questionnaire, Questionnaire Cover Letter, Tests:		
Semi-Structured Interview Questions	2	December 14, 2016
Email Quesionnaire	2	December 14, 2016
Letter of Initial Contact:		
Email Invitation	2	December 14, 2016

The application for ethical review and the document(s) listed above have been reviewed and the procedures were found to be acceptable on ethical grounds for research involving human subjects.

This study has been approved either by the full Behavioural REB of the UBC Okanagan or by an authorized delegated reviewer