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Medium of Instruction in Thai Science Learning

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Medium of Instruction in Thai Science Learning

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by

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ABSTRACT OF THE THESIS

Medium of Instruction in Thai Science Learning

by

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Master of Arts in Education

University of California, Los Angeles, 2013

Professor Alison L. Bailey, Chair

The goal of this study is to compare classroom discourse in Thai 9th grade science lessons with English or Thai as a medium of instruction. This is a cross-sectional study of video recordings from five lessons in an English-medium instruction class and five lessons in a Thai-medium instruction class from a Thai secondary school. The study involved two teachers and two groups of students. The findings show the use of both English and Thai in English-medium lessons. Students tend to be more responsive to teacher questions in Thai than in English. The findings suggest the use of students' native language during English-medium lessons to help facilitate learning in certain situations. Additionally, the study provides implications for research, practice and policy for using English as a medium of instruction.

The thesis of Natpat Chanjavanakul is approved.

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University of California, Los Angeles

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Introduction

As English has increasingly become important in the Thai economy, the use of English-medium instruction in elementary, secondary and higher education has steadily increased (Phonlabutra, 2007). Nonetheless, there are no systematic data about the implementation and performance of English-medium instruction in Thailand (Bax, 2010). Consequently, this study aims to gather data about the similarities and differences of classroom interactions during Thai-medium and English-medium science instruction in a Thai secondary school in order investigate effects of medium of instruction on classroom discourse and provide recommendations for future research, practice and policy.

As a result of English being declared as the sole official working language of the Association of Southeast Asian Nations (ASEAN) and the increased use of English in a globalized world, the trend of using English as a medium of instruction in East Asia and Southeast Asia is significantly increasing (Kirkpatrick, 2008, 2011, 2012a). However, most students do not have sufficient English proficiency to learn content by using English as a medium of instruction, especially for cognitively demanding subjects such as science and mathematics. Additionally, countries in Southeast Asia lack qualified teachers who can teach using English as a medium of instruction (Kirkpatrick, 2012b). These issues result in students losing opportunities to acquire skills and knowledge for the sake of improving their English. While nobody would disagree that English proficiency is beneficial in today's globalized economy, is using English as a medium of instruction the best way to acquire English proficiency? Are there any unexpected consequences from using English as medium of instruction? These questions underscore the need to investigate the burgeoning practice of using English as a medium of instruction in Southeast Asian countries.

English-medium Instruction in Thailand

The majority of Thai people use Thai as their first language (Kirkpatrick, 2012a). Some regions may have different dialects, but standard Thai (Central Thai) is dominant in compulsory education (Kirkpatrick, 2012a). In Thailand with tourism as its main income source, English is considered essential for employment and business opportunities. Despite its importance, however, English proficiency among the Thai population is very low. According to the English Proficiency Index (EPI), which measured two million adults on their English proficiency using online testing, Thailand is categorized as having "Very low proficiency," whereas Japan and China were categorized as having "Moderate" and "Low Proficiency," respectively (Katsos, 2012). The situation highlights both the high demand for English language skills and the wide gap to be filled in order to achieve widespread proficient use of English (Bax, 2010).

The Thai K-12 education system generally uses standard Thai (Central Thai) language as a medium of instruction with English taught as a foreign language subject beginning with the 1st grade (Kirkpatrick, 2012a; Ministry of Education, 2008). Thai Ministry of Education introduced a new form of English learning in public schools in 2002 to improve Thai students' competitiveness in the global economy (Phonlabutra, 2007). In Thailand, English-medium instruction is referred to as an "English Program." However, the term *English Program* is considered confusing among educators (Bax, 2010), as some private schools refer to their English-medium instruction as *bilingual programs*. For the purpose of this study, we will use the term *English-medium instruction* (henceforth EMI) to refer to non-language content (i.e., academic subjects such as science, mathematics, etc.) instruction in English.

Even though the Thai Ministry of Education has issued a set of regulations regarding the format of EMI in K-12 education, most schools have considerably high autonomy in terms of

curriculum and management (Bax, 2010). There are no official content standards and standardized evaluations specifically for EMI. The Thai Ministry of Education instructed that all EMI programs should use the same learning standards as Thai-medium instruction programs (Phonlabutra, 2007). The lack of official learning standards in English means there are no textbooks designated for EMI. Consequently, many schools opt to produce their own books, while others import them from foreign countries. The situation makes the quality of EMI highly inconsistent across the country. Moreover, there is no regulation regarding the English proficiency of students enrolling in EMI. Since schools offering EMI are permitted to charge higher tuition than regular Thai-medium instruction, many schools tend to accept students into EMI regardless of the students' English proficiency. This situation creates problems for students, especially when learning complex subjects using the English language. The Office of the Basic Education Commission conducted evaluations of EMI in 2003 and 2004. Results indicated the lack of supporting materials and qualified teachers and the challenge faced by students who do not understand content taught in English (Phonlabutra, 2007).

In spite of these challenges, there are increasing numbers of Thai students enrolling in EMI (Bax, 2010), partly as a result of parents and governments believing that the best way to learn a language is to use it as a medium of instruction (Kirkpatrick, 2012a). However, despite the increase in demand for EMI from parents and the increased number of schools offering EMI, the Ministry of Education does not have any systematic data concerning the effectiveness and impact of EMI among Thai students. This results in the need for research into this area to inform all stakeholders about this problem.

Literature Review

This study focuses on Thai students as English language learners (ELLs) learning science using English as a medium of instruction. For this study, the focus is on secondary students; therefore, most students are assumed to have mastered Thai literacy according to their age and level of education. The literature in this area is drawn from different contexts. For clarification purposes, the following terms are used throughout this proposal. Students' native or first language is referred to as *first language* (L1). In this study, we do not give importance to the distinction between students' foreign and second language. The term *second language* (L2) is used to refer any language other than students' native language (Lo & Macaro, 2012). The medium of instruction (MoI) in this study refers to the language used during the instructing content of non-language subjects (Lo & Macaro, 2012).

There are several terms for teaching academic content through the use of a L2 as a MoI (Lo & Macaro, 2012). For example, L2 MoI is usually called Immersion in Canada, Content-based instruction (CBI) in the U.S., English-medium instruction (EMI) in Hong Kong, and Content and Language Integrated Learning (CLIL) in Europe (Lo & Macaro, 2012; Wannagat, 2007; Yip & Tsang, 2007). For the purpose of consistency, we use the term *L2-medium instruction* for all non-language content instruction using students' L2. In the context of Thai education, instruction using Thai as a MoI will be referred to as TMI and instruction using English as a MoI will be referred to as EMI.

Literature on content-based instruction indicates using English (L2) as a MoI in content instruction has two goals: language acquisition and content learning (Stoller, 2004). Several studies on content-based instruction have examined the use of English (L2) as a MoI in content learning; however, the impacts of content-based instruction on language and content outcomes

still need to be researched further (Duff, 2001). Studies in other countries have shown that content learning in L2-medium instruction has negative effects on students in comparison to content learning in L1-medium instruction (Marsh, Hau, & Kong, 2000; Salleh, Venville, & Treagust, 2007; Yip, Tsang, & Cheung, 2003). Nonetheless, a study of Singaporean education showed that students could successfully master science content using L2-medium instruction (Dixon, 2005). These conflicting research results suggest that there is a need for further studies on L2-medium instruction in secondary students' science classrooms.

Theoretical Framework

Linguistic interdependence and threshold hypotheses. The linguistic interdependence hypothesis asserts that L2 acquisition is better without the loss of L1 proficiency and that the proficiency of L2 partially depends on L1 development (Cummins, 1979). This shows that, in order to achieve the goal of L2-medium instruction which is L2 proficiency, L1 development cannot be neglected. Furthermore, the threshold hypothesis posits that, in order to achieve the benefits of bilingualism, there is a minimal threshold of L1 proficiency required (Cummins, 1979). The required threshold level is likely to depend on the age of schooling. Both hypotheses support the importance of L1 to L2 acquisition. In countries where mainstream students speak L1 and there is a strong desire to learn L2, L1 instruction could be neglected if educators and parents are not aware of the importance of L1 on L2 acquisition. The threshold hypothesis takes L1 proficiency and age into consideration. Based on these hypotheses, early-start L2-medium instruction may cause less negative effects than late-start L2-medium instruction due to the lower demand on formal language.

Roles of language in science education. According to Vygotsky (1978), learning is constructed through individual and social interactions. In this view, the development of science

depends on the communication of members in the scientific community (Driver, Asoko, Leach, Mortimer, & Scott, 1994; Hogan & Corey, 2001; Lee & Fradd, 1998). In classroom science, "the mastery of science is mainly a matter of learning how to talk science" (Lemke, 1990, p. 153). While teachers and students can also use nonverbal symbols to facilitate the meaning-making process, these symbols cannot speak for themselves. Mortimer and Scott (2003) asserted, based on Vygotsky's sociocultural theory, that talk facilitates the meaning-making process, which is at the heart of learning. Learners use language in the meaning-making process to represent their thoughts, engage in the negotiation of meaning with others and construct their own concept understandings. Based on this view, we can investigate learners' thoughts and meaning-making processed by investigating their use of language.

Learning science in L2-medium (English) instruction presents challenges specific to non-English native speakers for several reasons. The appropriation process of scientific discourse is more difficult for non-western non-English native speakers because of cultural and linguistic discrepancy (Newcombe et al., 2009; Rosebery, Warren, & Conant, 1992). Moreover, the patterns of communicating scientific knowledge differ across languages and cultures (Lee & Fradd, 1998). For example, some non-native speakers use the communication patterns of their L1, and some use gestures more often than their native English peers. Furthermore, Collison (1974) found that learning science in L2 negatively affected students' scientific concept development. These findings underline the importance of language in science learning.

Effects of MoI on content learning. According to the existing literature, we may divide studies into two groups based on their contexts. The first group consists of studies of non-mainstream students whose L1s are not the same as mainstream students. In this context, the language required to function in society is the students' L2, while the L1 might be used less

often. Studies in this group are usually from English-speaking countries such as the U.S., the U.K., Australia and New Zealand. The other group includes studies from countries where L1s are commonly used in society, but another language is usually associated with high educational or economic status. In many countries, the language was introduced to the population during a colonial period; often, the language with high social status is English which is seen as an essential tool to gain high education and a well-paid job. The L1 in this context is generally widely used in society while the L2 is considered an advantage.

English language learners in English-speaking countries. Research has shown that L1 proficiency influences academic success even when instruction is in L2 (García-Vázquez, Vázquez, López, & Ward, 1997; Willig, 1985). A study of Hispanic 6^{th}-12^{th} graders showed a strong correlation between L1 literacy skill and achievement in standardized tests in English (García-Vázquez et al., 1997). Studies in science education indicate that ELLs often struggle with science instruction in L2 (Tobin & McRobbie, 1996; Yip & Tsang, 2007). For instance, a study in a Russian-English bilingual secondary classroom showed that students' limited English proficiency affected students' willingness to participate in classroom discussion (Lemberger, 2002).

There are some intervention studies with results that highlight the importance of L1 in L2 science instruction. For instance, a study about online science inquiry indicated that lessons using both English and Spanish worked better with Spanish-speaking students than lessons that used only English (Clark, Touchman, Martinez-Garza, Ramirez-Marin, & Drews, 2012). Nonetheless, some intervention research shows that there are other ways to help ELLs learn science without using L1. A study by Amaral, Garrison, and Klentschy (2002) about an inquiry-based science program found that inquiry-based lessons were suitable for ELLs because the

lessons encouraged collaborative efforts which aided ELLs' oral English practice. Inquiry-based lessons also used other non-linguistic tool such as real life objects, pictures and graphs to help ELLs by relying less on students' English proficiency (Amaral et al., 2002). These intervention studies suggest that, while L1 is beneficial for ELLs in a science classroom, it might not be necessary if there are other aids involved.

While studies with immigrant students can provide some information about using L2 in content learning, the context of ELLs as immigrants in English-dominant countries is very different from the context of ELLs learning English in their native countries. Even though both groups have to face the challenges of learning academic English and subject contents, immigrant youths have to face several stressors associating with adjusting to a new environment (Suarez-Orozco, Hee Jin, & Onaga, 2010). Furthermore, immigrant students are typically in schools with an especially high proportion of racial and ethnic minority students (Suarez-Orozco et al., 2010). These schools are associated with several negative school characteristics such as low achievement rates and high dropout rates (Suarez-Orozco et al., 2010). On the contrary, ELLs studying content knowledge in English in their homelands are generally high-achievers in schools equipped with required resources (Yip & Tsang, 2007; Yip et al., 2003). Regarding home situations, immigrant youths are found to speak their native languages outside the classroom most of the time (Carhill, Suarez-Orozco, & Paez, 2008) which is similar to ELLs in their home countries. However, parents of immigrant students are typically not well-equipped to help their children with studying (Suarez-Orozco et al., 2010), while ELLs in their home countries are generally from the upper middle class and above due to the relatively high expense in attending schools using English as a MoI.

English language learners in non-English-speaking countries. Similar to research on non-English native speakers in English-speaking countries outlined above, studies in several countries have shown the negative effects of EMI on ELLs. A study of 85 elementary students in Ghana showed that students' limited ability to express their ideas negatively affected their conceptual development (Collison, 1974). Similarly, a study of 75 primary students in Brunei demonstrated that transitioning from a native to an English-language MoI limited students' abilities to construct and express their understandings of science (Salleh et al., 2007). A quantitative study in Nigeria also found that students in EMI scored lower on a science achievement test than those in L1-medium instruction (Ehindero, 1980). These studies underline the importance of language ability in scientific conceptual development in elementary students.

Studies in secondary students indicate similar problems. Longitudinal studies of secondary students in Hong Kong also indicated negative impacts of changing from a Chinese (L1) to an English (L2) MoI (Yip & Tsang, 2007; Yip et al., 2003). Results showed that despite students' higher academic achievement at the beginning of secondary school, students in EMI performed significantly lower in non-language subjects than students in Chinese-medium instruction. Moreover, results indicated a low self-concept in science for students in EMI compared to their peers in Chinese-medium instruction. Researchers suggested that this was most likely due to students' struggling with science learning in English (Yip & Tsang, 2007).

Another mixed-method study with Hong Kong students investigated the classroom discourse patterns in 9th and 10th grade science classrooms in Chinese and English MoIs (Lo & Macaro, 2012). The study showed that teachers were more dominant in the English-medium than in Chinese-medium instructions. Using the classroom talk categorization developed by Mortimer and Scott (2003), the study showed that in English-medium classrooms teachers were more

authoritative and provided students with fewer opportunities to develop their own ideas. Additionally, the study analyzed the teacher's questioning patterns based on Tsui's (1985) categorization. Results showed that teachers in EMI initiated questions less often than those in Chinese-medium instruction. The qualitative analysis illustrated that teachers' questioning patterns in EMI seemed to be less effective in drawing out students' responses (Lo & Macaro, 2012). These results confirm findings from a previous study in Hong Kong secondary bilingual education showing that while bilingual education (i.e., using English as a MoI in most subjects) had positive impacts on English and Chinese achievement and a small negative impact on math but large negative impacts on science, geography, and history learning (Marsh et al., 2000).

Nonetheless, some research presents no negative evidence of L2-medium instruction. In Singapore, a majority of students speak English as a L2 with Chinese or Malay as their native languages (Dixon, 2005). Most students start EMI in the first grade contrary to Thai education where students and parents have an option to attend EMI at any time they prefer. According to Dixon (2005), Chinese is a dominant language in everyday life while English is a dominant language in education and in one's professional life. A survey of oral and written language preference showed that Singaporeans used Chinese with oral communications including television and radio consumption, but they preferred English for reading and writing. The quantitative analysis showed highly successful academic achievements in math and science by Singaporean students. These findings challenge the results of research in other countries where L2-medium instruction has been found to have negative effects. However, it is difficult to draw a conclusion from L2-medium instruction in comparison to L1-medium instruction in Singapore because there were not enough students in L1-medium instruction to compare with those in L2-medium instruction.

Classroom discourse in science lessons. Studies on classroom discourse can help in understanding the phenomenon of EMI and its impacts in the classroom. According to Reyes (2008), students use a variety of discourse strategies in EMI science lessons. The study shows that students use L1 to help interact with peers and their teacher. The study also found the teachers' use of code-switching helped students to understand scientific concepts and to develop literacy skills in an academic setting. A study of EMI science classrooms in the Philippines found that when the classroom mode was informative, meaning the teacher mainly provides information, the strategies the teacher used to help increase students' understanding are translation and paraphrasing (Buri, 2012). The researcher concluded that translation might help students understand content but if the goal of using English as a MoI was for students to understand utterances in English, the paraphrasing strategy should be tried first before using the translation strategy.

According to Duschl, Schweingruber and Shouse (2007), the main activity in science communities is argumentation to establish agreements within the communities. Despite its importance in science, argumentation is not common in science classroom discourse. The literature shows that most classroom talk comes from teachers. The usual classroom discourse is the initiation-response-evaluate triad (Mehan, 1979), which consists of a teacher asking a question usually with a known answer, a student responding and a teacher providing evaluation. A teacher generally uses this type of discourse to determine if a student knows the answer to the question, not to genuinely ask for the students' thoughts.

Rationale

Current literature indicates that using L2-medium instruction can have negative effects on science achievement (e.g. Lee, 2005; Yip & Tsang, 2007; Yip et al., 2003). Scientific

understanding includes constructing complex concepts and abstract thinking, processes that require a significant language component (Reyes, 2008). Moreover, science has its own language that students need to master (Case, 2002). Many science classroom activities in which students have to express their understanding of scientific concepts pose a challenge for ELLs (Shaw, Bunch, & Geaney, 2010). A major obstacle can occur if students have to use the language that they are not proficient in. Several studies have indicated that, when instruction is in L2, students' L2 proficiency poses a limit to science achievement (Lee, 2005; Torres & Zeidler, 2002).

Using L2-medium science instruction when students are not proficient in L2 can lead to several negative consequences. Firstly, it could cause students to have a low self-concept about science (Yip et al., 2003). These students are more likely to perform poorly in science (Yip & Tsang, 2007). The combination of a lack of scientific understanding and low self-concept in science could result in students avoiding science-related fields. Furthermore, even though students are not interested in pursuing science-related fields, scientific literacy is still an important skill in a global economy where English is the de facto language in the world (Graddol, 2006). Students should be able to interpret science information and make critical decisions for themselves (Choi, Lee, Shin, Kim, & Krajcik, 2011). Thus, using L2-medium science instruction might negatively affect students' scientific literacy development.

According to Vygotsky's sociocultural view, people use language to construct knowledge through social interactions (Vygotsky, 1978). This points out that examining classroom interactions can provide us insights into scientific knowledge development (Hogan & Corey, 2001). Moreover, further studies on teacher-student interactions and classroom discourse can provide insights into how L2-medium content instruction affects students' language and content learning (Gibbons, 2003). Therefore, I chose to investigate interaction patterns in EMI and TMI

science lessons to determine if there are similarities or differences between lessons using different languages for instruction. Since there is no systematic data about EMI and TMI science instruction in Thai students (Bax, 2010), the objective of this study is to examine and document classroom interaction patterns in Thai students to help guide future research in this area rather than investigating learning outcomes.

Method

Research Questions

What are the salient discourse patterns in EMI and TMI 9th grade science lessons?

1. What are the frequencies of teacher questions and student responsiveness to teacher questions in EMI and TMI lessons?
2. How do the frequencies of teacher questions and student responsiveness differ by language (English or Thai) in the EMI lessons?
3. What are the key characteristics of teacher-student interaction patterns in EMI and TMI lessons?
4. What are the similarities and/or differences in types of teacher questions in EMI and TMI lessons?
5. What are the characteristics of discourse patterns in EMI lessons?

Research Design

This research is a qualitative study of instructional interaction in authentic classroom settings. The aim is to examine the discourse patterns in EMI and TMI science lessons with a view to characterizing features that are influenced by the use of different languages for instruction. This study's focus is on a group of Thai secondary students and their teachers in the context of EMI and TMI science lessons. This particular context has rarely been studied in detail.

According to the constructivist view, the qualitative study design is appropriate with this study's aim to gain an understanding of the learning and instruction process in this particular context (Mertens, 2010). Furthermore, because the study is focusing on a new group of participants, the study may stimulate the generation of additional questions. In order to be open to such emerging issues, a qualitative design is suitable for this exploratory stage in the research enterprise (Creswell, 2012).

Setting and Participants

The participants in this study were selected by convenience sampling. I had existing relationships with the head of the "English Program" (EMI) department and science teachers. They were interested in the study and gave me an opportunity to observe their teaching. The site of this study was a large secondary public school in Bangkok. The education system in Thailand consists of 6 years in elementary school and 6 years in secondary school. In the secondary level, the 1st year is called Mattayom suksa 1 (M.1), 2nd year is called Mattayom suksa 2 (M.2), and so on until the 6th year as Mattayom suksa 6 (M.6). Thai compulsory education is until M.6; thus, the government subsidizes the tuition fee for all students in the normal TMI program until M.6.

The EMI program is optional. Parents and students can choose to enroll in the EMI program if they prefer. Students have to pass a certain level of English proficiency test arranged by the school before being accepted into the EMI program. Since the EMI program is not compulsory, the government does not provide any tuition subsidy. Thai Ministry of Education allows schools that provide EMI to charge a higher amount of tuition compared to what the schools charge students in the TMI program. The tuition fee for the EMI program is considered to be similar to the tuition fee of normal Thai private schools.

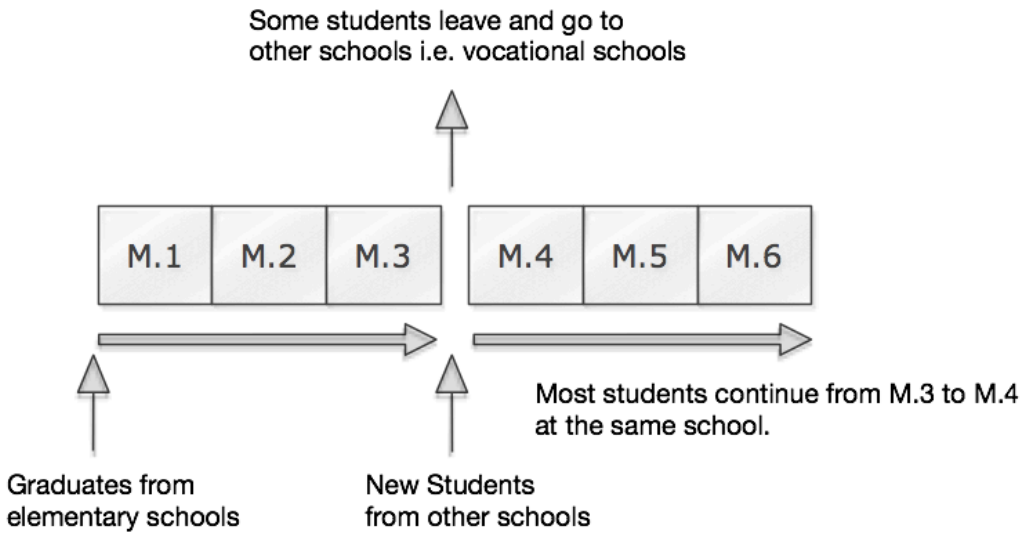

Figure 1. Diagram of organization of students attending the selected school

The school has approximately 4,000 students from M.1 to M.6. The normal Thai program uses TMI for all subjects including English and foreign languages for all grade levels. The EMI program uses EMI for all subjects except Thai language and certain social studies subjects. The majority of students study at this school start from M.1 and continue through M.6. Some students may choose to leave the school after M.3, and the school generally admits a small number of new students to start at M.4. For this reason, this study selected M.3 (9^{th} grade) classrooms as research participants as students would have been studying in the MoI of choice for at least two years. The age of students in M.3 ranged from 14-16 years old.

The EMI program has its own building separate from the TMI program. All classrooms for the EMI program are air-conditioned, while not all classrooms of the TMI program are. Students from both programs use the same facilities, i.e. library, gym, science lab, workshop, meeting hall, etc. Teachers for the TMI program are full-time government employees. On the contrary, many teachers for the EMI program are considered part-time school employees. Some

teachers for EMI are English native speakers from other countries. Expat teachers usually teach English language as a subject, while Thai teachers generally teach other content subjects.

Teachers in both TMI and EMI programs were informed about the study. Participants were selected based on availability and willingness to participate in the study. Two teachers decided to participate. Each teacher selected one M.3 that they were teaching to be included in the study. Teachers were told to select the classes that had similar general academic and science achievement. At the time of this study, there were approximately 800 students in the TMI program and 150 students in the EMI program in the M.3 (9^{th} grade) level. Each TMI class has 50-55 students per class, while each EMI class has approximately 30 students per class.

There are several limitations to this sample. Because these two classes have two different teachers, each teachers' individual teaching style, skills, knowledge, attitudes, biases and personal characteristics could affect the findings. Additionally, students from the two classes are not systematically comparable. Data about students' learning development, primary education, family background, informal education, etc. are difficult to obtain and will not be considered in the study. The study aims to explore classroom interactions in different languages of instruction to provide a basis for future research in this population. We may not be able to compare all classrooms directly, but the data can be informative about actual classroom interactions in different languages of instruction and may help the field understand the possible differences between classrooms using different languages of instruction.

Data Collection

The data collection was conducted by an external volunteer who is familiar with the setting and has a background in social science research. The volunteer is a Thai native speaker

and is fluent in English. The volunteer administered teacher questionnaires and conducted video recordings of five lessons for each of the two selected classrooms.

Teachers were asked to complete simple questionnaires about their students and classes (i.e. students' general academic achievement, students' English proficiency level, textbooks, students' science performance, etc.; See Appendix). The purpose of this teacher questionnaire was to gain demographic and background information about teachers and their students. Video recording was the selected method of data collection for classroom discourse. The video recording is suitable in capturing classroom discourse in a natural setting in a non-obtrusive way. Limitations of this method include that the video recording may be difficult to interpret and may not be able to capture some incidents that would otherwise be noticed by observation. However, the observation method is not feasible given the timeframe of this study; thus, video recording seems to be the most appropriate. There were a total of five fifty-minute lessons of video recording for EMI and TMI classrooms. As a native Thai speaker and a fluent speaker of English as a L2, I transcribed all the video recordings. Additionally, I transcribed selected transcriptions for illustration purposes.

Measures

The researcher. According to Miles and Huberman (1994), the researcher in qualitative research is considered the main measurement tool. Therefore, it seems appropriate to give some background about myself to help inform how my experiences could influence the findings of the study (Bazeley, 2013). I am a Thai native speaker and am fluent in English. I learned English as a L2 in Thai schools beginning in the 1st grade. My K-12 and college education were all in Thailand and in the Thai language. My graduate education was in English and in the United States. I have a one-semester teaching English language experience in a Thai secondary school

and a one-year teaching science experience in English-medium in a Thai bilingual secondary school. The setting of this study was the school that I had studied at for six years from 7th to 12th grades. During the time I studied there, only the TMI program was available. Based on site visits and video observations, my experience in 7th to 12th grades was similar to the current TMI program regarding the size of the classroom, facilities, classroom discourse and learning content. Furthermore, the size of the classroom, facilities and classroom discourse in the EMI program were similar to what I experienced as an English-medium science teacher in the Thai bilingual school.

Teacher's utterances. Teacher's discourse was divided into utterances. Utterances are defined as "groups of words expressing a single idea or proposition" (Genishi & Glupczynski, 2006, p. 665) and all phrases attached to the idea or proposition. The example of the parsing procedure is shown in Example 1. Teacher utterances were categorized as either in English or Thai language. If two languages were used in an utterance, the utterance was categorized based on the language that was mainly used in the utterance, or if an utterance used an equal amount of English and Thai words, the utterance was categorized based on the language used to express a main idea of the utterance. The proportion of teacher questions to total teacher utterances in each lesson using English or Thai language was calculated to illustrate the frequency of teacher questions as a part of teacher utterances.

Example 1

> Teacher: Look at the picture here. This is how they measure. Counting the number of the population of some animals on the rocky shore. บนพื้นที่หาดหิน ใช้นับเหมือนกัน [(They) also use counting on the rocky shore.]

Note. Translations are in brackets. Additional descriptions and/or explanations are in parentheses.

In this example, the sentence "Look at the picture here." is counted as one utterance because it represents one proposition which is giving a command to students to look at the picture. "This is how they measure. Counting the number of the population of some animals on the rocky shore." is parsed out as two utterances because of a short pause between the word "measure" and "counting." When the teacher reiterated the content in Thai as "บนพื้นที่หาดหิน ใช้นับเหมือนกัน [(They) also use counting on rocky shore.]", this is counted as one utterance, even though there was a small pause between the phrase "บนพื้นที่หาดหิน" and the phrase "ใช้นับเหมือนกัน." This is because each phrase does not make sense by itself, and the two phrases together represent only one proposition - (They) also use counting on the rocky shore. This is also a feature of Thai oral language in that the subject can be omitted.

Teacher questions. Transcripts from all ten lessons were coded using magnitude coding (Saldaña, 2013). The magnitude coding was used to indicate the presence of questions and frequency in teacher discourse. For this section, the unit of analysis is a teacher's question and the presence or absence of students' responses to the question. This study only focused on authentic questions. The rhetorical questions were not coded. From this point on, a teacher question is defined as the teacher's question that the teacher intended for students to answer. To distinguish authentic questions from rhetorical questions to which the teacher did not expect a student to answer, the length of pause after the question (indicating that the teacher was waiting for students to answer) and characteristics of sentences within the context were used. An example of how authentic and rhetorical questions are distinguished is shown in Example 2. Questions were then categorized based on the language the teacher used in asking questions.

Example 2

Teacher: Deforestation แปลว่าอะไร? [What does deforestation mean?]

Students: ตัดไม้ทำลายป่า [Destroy the forest.]

Teacher: ตัดแบบไหน? [In what way?]

Student: Clear

Teacher: Clear cutเลย Clear cutเลย ตัดให้เรียมนะคะ เพราะงั้นแน่นอน จากที่มันเคยมีต้นไม้มันจะกลายเป็น? [Totally clear cut. Totally clear cut. Cut all of them (polite marker). Therefore, from having trees, it is turned into?]

Student: ไม่มี [None.]

Teacher: ทราย ใช่ไหม เพราะว่าไง ดินมันจะเป็นไง ดินมันจะไหลไปนะคะ [Sand, right? Because what? Because the soil will what? The soil will erode (polite marker).]

Note. Translations are in brackets. Additional descriptions and/or explanations are in parentheses.

From Example 2, the questions " Deforestation แปลว่าอะไร?" [What does deforestation mean?], "ตัดแบบไหน?" [In what way?], and "เพราะงั้นแน่นอน จากที่มันเคยมีต้นไม้มันจะกลายเป็น?" [Therefore, from having trees, it is turned into?] are coded as authentic questions because the teacher gave a small pause after each question to wait for student(s) to answer. On the contrary, the phrases "ทราย ใช่ไหม เพราะว่าไง ดินมันจะเป็นไง" [Sand, right? Because what? Because the soil will what?] are not coded as authentic questions because even though the sentences are in question form, the teacher did not expect students to answer. This was observed by the absence of a pause after the questions and the presence of the answer to the questions provided by the teacher immediately after saying the utterances.

Students' responses. Students' responses for teacher questions were coded into one of four types: 1) no response, 2) a single student's response, 3) students' responses, or 4) the

teacher and students' responses. No response means there was no response from any student following the teacher's questions. A single student's response refers to any response to teacher's questions that came from only one student. Students' responses refer to any response to teacher's questions that came from two or more students. The teacher and students' responses refer to when the teacher provided the response along with students.

Student responsiveness. Student responsiveness was calculated as the proportion of the number of students' responses by the number of teacher questions. I combined types 2-4 of students' responses together because the aim of this analysis is to examine how responsive students are to teacher's questions. This goal is to compare if there is any difference in students' responsiveness when a teacher uses different language(s) of instruction. Any cross-linguistic exchange in which the teacher used one language but received a response in the alternate language will be discussed in the eliciting response in the alternate language section below.

Analytic Plan

Teacher questionnaire. Findings from the teacher questionnaire are intended to provide basic information about teachers and students who participated in the study and to provide a context for results of the study.

Teacher questions and student responsiveness. Because the interaction between teacher and students are one of the important factors in learning science (Mortimer & Scott, 2003), I want to examine if there are any differences in frequencies of teacher questions and student responsiveness in classrooms with different languages of instruction. Frequencies of teacher questions in each EMI and TMI lessons were counted and averaged. Additionally, to investigate the influence of language of instruction within the same classroom, frequencies of teacher questions in English and in Thai for each lesson were counted and averaged. The number

of student responses for each teacher's questions were counted according to teacher's language of questions and class types (EMI or TMI). The instances in which the teacher asked in one language and elicited a response from students in the alternate language were not included in this section, but will be analyzed separately. In order to examine if the language the teacher used in asking questions has an influence on student responsiveness or not, the proportions of student responsiveness were calculated according to teacher's language of questions and class types. If there is a difference, a chi-square will be performed to determine if the difference is significant.

To further illustrate differences of teacher questions based on languages of instruction and class types, the proportions of teacher questions to total teacher utterances and rates of teacher questions per minute of instruction were calculated. I made comparisons of proportions of teacher questions to total teacher utterances and rates of teacher questions per minute of instruction between English and Thai questions in EMI lesson and between EMI and TMI lessons. If there is any difference, a t-test will be performed to determine significance of the difference.

Teacher-student interaction in classroom talk patterns. Two types of classroom talk patterns were examined in this study. The first one is I-R-E/F (Initiation-Response-Evaluation/Feedback). This pattern starts with an initiation from a teacher, and the response from a student followed by the teacher's evaluation. The second pattern is I-R-F-R-F (Initiation-Response-Feedback-Response-Feedback) and differs from the first one by the way in which the teacher elaborates on a student's response or provides students with feedback in assisting them in their meaning-making processes. The second pattern can occur in a chain reaction manner (I-R-F-R-F) wherein a teacher provides elaborative feedback and receives a student's further response. This is a classroom interaction in which teacher helps students develop their own ideas,

whereas, via the first pattern, the teacher's authoritative interaction pattern is emphasized (Mortimer & Scott, 2003). After coding an interaction as I-R-E/F or I-R-F-R-F, the interaction was further categorized as English, Thai, or bilingual based on the language(s) used in the interaction.

The I-R-F-R-F interaction pattern is considered desirable for a science classroom as it can lead to students' constructing their own knowledge with the teacher's guidance (Mortimer & Scott, 2003). To investigate two types of teacher-student interactions, the frequencies of I-R-E/F and I-R-F-R-F interactions were counted. For the EMI lesson, the interactions were categorized based on whether the interactions were in English, Thai or bilingual. The purpose is to examine if there is any difference of interaction patterns based on languages of instruction and class types.

Types of teacher questions. Teacher questions were coded according to types of teacher questions. In this study, teacher questions were categorized into two major types: display and genuine questions. Display questions are knowledge-checking questions (Tsui, 1995), whereas genuine questions are questions to which the teacher does not have the answers (Lo & Macaro, 2012; Tsui, 1995). As a Thai native speaker and being fluent in English who has a background in educational research, I coded all the teacher questions. In order to determine the reliability of coding procedure, at least 20 percent of questions from every lesson were also coded by a graduate student in biology who is a Thai native speaker and fluent in English. In coding two main question types (display and genuine), the coders agreed on 137 out of 139 codes (k=.83). Two coders agreed on 131 out of 132 codes for types of display questions (k=.98). In coding types of genuine questions, two coders agreed perfectly (k=1.0) on five out of five codes.

The purpose of examining display and genuine questions is to examine if there are any differences in types of questions that the teacher asked using different languages and in different

class types. For EMI lessons, the numbers for each type of question in each lesson were compared based on the use of English or Thai language. For TMI lessons, the number of each type of question was compared between lessons and with EMI lessons. If there is any difference in types of teacher questions, a t-test will be performed to determine statistical significance of the difference.

Discourse patterns. Because the teacher and students used both English and Thai languages in EMI lessons, I selected EMI classroom discourse to further explore discourse patterns in different languages of instruction. TMI lessons were not analyzed in this section. I coded the transcript using open coding and process coding for analyses in this section. The open coding process refers to the initial coding phase with the goal of exploring the data (Bazeley, 2013). The open coding process was considered appropriate for analyzing discourse patterns in this study because this type of discourse has not been studied extensively in an English-Thai bilingual context. Thus, the open coding method was suitable for developing initial codes. The process coding used "–ing" words to code the activity with the purpose of searching for continuous action and interaction (Saldaña, 2013). The process coding is appropriate because the aim of this section is to search for what the teacher and students did in classroom discourse. Using both the open and process coding provides insights into characteristics of classroom discourse patterns in EMI lessons.

Example 3. Process Coding

Teacher: Urochordate, they have the notochord only in just one stage of life, for example in the lava stage. They have a Notochord. You can see. This is the notochord. The small rod shape that from head part to the tail. And when they become adult, it's gone. That structure is gone.	Teaching Introducing new contents
เป็นไงคะ มีเฉพาะตอนที่เป็นอะไรเท่านั้น[So they only have it when they are?]	Asking a display question
Student: เด็ก [Young.]	
Teacher: เป็นตัวอ่อน เป็นเด็กนะคะ จนโตมีไหม? [When they are lava. When they are young. Do they have it when they are adult?]	Using Thai to check students' understanding of what was said in English
ไม่มี แต่มีลักษณะอื่นก็เช่น pharyngeal slit นะคะ [No, but they have other characteristics such as pharyngeal slit.]	

Note. Translations are in brackets.

The example of process coding is presented in Example 3. The teacher's first few sentences were teaching and introducing new content so they were coded as such. The teacher's question "So they only have it when they are?" is asking about what had just been said in order to check students' understanding. The teacher then did the same using the question "Do they have it when they are adult?" From this second question, I noticed that the teacher used Thai to check students' understanding. The example shows that using process coding helped in characterizing classroom discourse pattern. In this example, process coding helped me recognize that the

teacher used Thai to ask questions to check if students understand what she had previously said in English.

To provide a more comprehensive picture of classroom discourse, transcripts were analyzed with the goal of exploring and characterizing teacher's classroom talk. I used open coding and process coding to investigate 20 percent of the transcripts in detail. Then I used these findings to develop a list of discourse patterns and their features and applied this list to the rest of the transcript with minor adjustments. An interesting pattern that will be analyzed and discussed separately is eliciting responses in the alternate language in EMI lessons.

Results

Descriptive Findings from Teacher Questionnaire

Both teachers who participated in the study were asked to complete a questionnaire soliciting basic information about teachers and their students prior to the video recordings of classroom teaching. The teacher for the EMI classroom had three years of science teaching and overall teaching experience. She has been using English as a MoI for three years. She held a Master's degree of Science in Environmental Biology. The textbooks she used in the classrooms were in English. She indicated that she partly used English and partly Thai in class. The teacher rated the average English proficiency of students in this class as intermediate. She rated the general academic achievement of students in this class compared to other students at the same grade level as average; however, she rated the science performance of students in this class as above average.

The teacher in the TMI classroom had two years of science teaching and overall teaching experience. He had used Thai as a MoI for two years. He held a Bachelor's degree of Science in Chemistry. The teacher indicated using Thai textbooks in class and used only Thai as a MoI. He

rated the average English proficiency of students in this class as beginner. He rated both the general academic achievement and science performance of students in this class as average.

Based on the findings from the teacher questionnaire, both teachers had less than five years of science teaching experience. Both teachers had only taught science at the middle school level. The teacher for the EMI class had more training in science as she held a Master's degree, while the teacher for the TMI class held a Bachelor's degree. Both teachers did not indicate having a post-secondary degree in teaching or education.

Teacher Questions and Student Responsiveness

According to Table 1, the number of questions asked in English and Thai by the teacher in each lesson varied. In EMI lessons 1 and 2, the teacher asked questions using English more frequently than using Thai, whereas in EMI lessons 3-5, she asked questions using Thai more frequently than using English. The total number of teacher questions in all five EMI lessons was 194 English and 235 Thai questions. The average number of teacher questions in an EMI lesson was 39 English and 47 Thai questions. Overall, the teacher asked Thai questions more frequently than English questions.

In all EMI lessons except lesson 4, students were more responsive to the teacher's Thai questions than to English questions. On average, the proportion of student responsiveness to teacher's English questions is .68, while the proportion of student responsiveness to teacher's Thai questions is .87. The result from a chi-square test shows that the proportions of student responsiveness to teacher questions significantly differ by language used, X^2 (1, N = 429) = 10.35, $p < .01$.

Table 1

Frequencies of Teacher Questions and Proportions of Student Responsiveness

Lesson	Teacher Questions	Student Responsiveness (Proportion)
English as a Medium of Instruction (EMI)		
1		
English	57	37 (.65)
Thai	27	23 (.85)
2		
English	28	21 (.75)
Thai	23	22 (.96)
3		
English	56	31 (.55)
Thai	72	59 (.82)
4		
English	27	23 (.85)
Thai	54	46 (.85)
5		
English	26	20 (.77)
Thai	59	54 (.92)
Total		
English	194	132 (.68)
Thai	235	204 (.87)
Thai as a Medium of Instruction (TMI)		
1-2 (Double period)	54	51 (.94)
3-4 (Double period)	27	26 (.96)
5	29	27 (.93)
Total	110	104 (.95)

Note. Each lesson is categorized by the language the teacher used for asking a particular question.

The number of teacher questions in the TMI class varied from 54 questions in lessons 1-2, 27 questions in lessons 3-4 and 29 questions in lesson 5. There were a total of 110 questions in 5 TMI lessons, which averaged to 22 questions per lesson. The proportion of student responsiveness to teacher questions in Thai lessons ranges from .93 to .96 in TMI lessons. On average, the proportion of student responsiveness to teacher questions in TMI lessons is .95.

Based on the findings, it seems that students were more responsive to teacher questions when the teacher used Thai rather than English in EMI. Specifically comparing the same teacher with the same group of students, students were more responsive to Thai questions than to English questions. Comparing EMI and TMI lessons, students were more responsive in TMI than in EMI lessons. However, a limitation for this comparison is that it could be a result from different characteristics of teachers and students. Nonetheless, the findings suggest that students are generally more responsive to teacher questions in Thai compared to those in English. This result supports research using Hong Kong secondary science classrooms that found fewer teacher-student interactions when the language of instruction was changed from Chinese to English (Lo & Macaro, 2012).

The proportion of teacher questions to total teacher utterances in EMI lessons can be categorized into either English or Thai. The proportion of teacher questions in English to total teacher utterances in English in each EMI lesson ranges from .12 to .19 with an average of .14. While the proportion of teacher questions in Thai to total teacher utterances in Thai in each EMI lesson varies from .08 to .15 with an average of .11. In general, the teacher in EMI lessons said questions in English in proportion to total English utterances more frequently than in Thai in proportion to total Thai utterances. Comparing proportions of questions within EMI lessons, the proportion of teacher questions in English (M = .14, SE = .02) is higher than the proportion of teacher questions in Thai (M = .11, SE = .01). Despite the numerical difference, the result is not statistically significant $t(8) = 1.90$, $p > .05$.

Rates of teacher questions per minute of instruction were calculated by using the number of teacher questions in one lesson divided by the total minutes of instruction in that lesson. Calculating the rate of questions, I used the total minutes of instruction without separating the

time by languages used as I aimed to present how often English and Thai questions occurred in each individual EMI lesson. The rate of teacher English questions per minute of instruction in each EMI lesson ranges from 0.61 to 1.42 questions per minute with an average of 0.98 questions per minute. The rate of teacher Thai questions per minute of instruction in each EMI lesson ranges from 0.57 to 1.83 questions per minute with an average of 1.19 questions per minute. Considering English and Thai questions combined for EMI lessons, the average rate of teacher questions in EMI lessons is 2.17 questions per minute. Comparing across EMI lessons, the rate of teacher English questions is higher than the rate of teacher Thai questions in lessons 1 and 2, whereas in lessons 3-5, the rate of teacher English questions is lower than the rate of teacher Thai questions.

In each TMI lesson, the proportion of teacher questions to total teacher utterances ranges from .09 to .20 with an average of .15. Comparing proportions of questions in EMI and TMI lessons, the proportion of teacher questions in TMI lessons (M = .16, SE = .03) is higher than the proportion of teacher questions in EMI lesson (M = .12, SE = .01). However, this difference is not significant $t(6) = .31$, $p > .05$.

The rate of teacher questions per minute of instruction in each TMI lesson varies from 0.57 to 1.90 with an average of 1.15 questions per minute. Comparing EMI and TMI lessons, the rate of teacher questions per minute of instruction in EMI lessons (M = 2.18, SE = .27) is higher than the rate of teacher questions in TMI lessons (M = 1.30, SE = .39). However, the statistical test shows that this difference is not significant $t(6) = .11$, $p > .05$

Teacher-Student Interaction in Classroom Talk Patterns

The frequency of I-R-E/F English interaction pattern in an individual EMI lesson ranges from 12 to 26 with an average of 19.4 interactions per lesson. The frequency of I-R-E/F Thai

interaction pattern in each EMI lesson varies from 17 to 49 with an average of 32.4 interactions per lesson. The bilingual I-R-E/F pattern ranges from 1 to 6 interactions per EMI lesson with an average of 3 interactions per EMI lesson. In each EMI lesson, there were more teacher-student interactions in Thai than in English and bilingual. An average frequency of I-R-E/F pattern in EMI lesson regardless of language of instruction is 51.8. On the other hand, an average frequency of the same pattern in the TMI lesson is 13.4. Comparing EMI and TMI lessons, it seems that there were more interactions occurring in the EMI lessons. Nonetheless, it may be inappropriate to compare the frequencies of this pattern directly between EMI and TMI classrooms as both classrooms involved two teachers and two groups of students. The I-R-F-R-F pattern is found to be less frequent in both EMI and TMI classrooms. An average frequency of I-R-F-R-F pattern in EMI lesson is 5.6 interactions per lesson, whereas an average frequency of the I-R-F-R-F pattern in TMI lesson is 2.4. Regardless of interaction pattern type, there were more interactions in EMI than TMI lessons.

Table 2

Frequencies of Teacher-Student Interactions

Lesson	I-R-E/F	I-R-F-R-F
English as a Medium of Instruction (EMI)		
1		
English	26	3
Thai	19	0
Bilingual	2	3
2		
English	15	2
Thai	17	2
Bilingual	3	0
3		
English	24	3
Thai	49	4
Bilingual	1	0
4		
English	20	1
Thai	34	3
Bilingual	6	1
5		
English	12	2
Thai	43	4
Bilingual	3	0
Total		
English	97	11
Thai	162	13
Bilingual	15	4
Thai as a Medium of Instruction (TMI)		
1-2 (Double period)	31	4
3-4 (Double period)	15	5
5	21	3
Total	67	12

According to the results, it appears that the teacher-student interactions occurring in the observed science classrooms in Thailand, regardless of the language of instruction, are mostly in the I-R-E/F pattern rather than in the I-R-F-R-F pattern. Findings from this study suggest that teacher-student interaction patterns in EMI and TMI classrooms are similar to those in traditional science classrooms (Duschl et al., 2007; Mortimer & Scott, 2003).

Types of Teacher Questions

Table 3
Types of Teacher Questions and Their Frequencies in an Individual English as Medium of Instruction (EMI) Lessons Divided by Language(s) Used

Teacher	1		2		3		4		5	
Questions	Eng	Thai	Eng	Thai	Eng	Thai	Eng	Thai	Eng	Thai
Display										
a) Factual	37	11	27	12	44	35	19	33	22	34
b) Yes/No	4	1	1	3	6	24	9	14	4	22
c) Alternative	3	0	0	1	1	0	0	0	0	0
d) Reasoning	1	1	1	1	3	1	1	0	0	1
e) Word Meaning	8	11	3	2	2	7	2	4	0	4
Genuine										
a) Opinion	1	0	0	0	0	1	0	4	1	1
b) Information	3	1	0	5	1	4	0	1	0	0

The data shows that the majority of teacher questions are display questions. Genuine questions were rarely used, and when they were used, they were more common in Thai (n = 17) than English (n = 6). Considering the display questions in the same language, the proportion of factual questions in English for each EMI lesson ranges from .61 to .85 and the proportion of factual questions in Thai for each EMI lesson ranges from .46 to .92. On average, the proportion of factual questions to total display questions in English (M = .76, SE = .05) is higher than the proportion of factual questions to total display questions in Thai (M = .64, SE = .08). This result shows that the teacher in EMI lessons asked factual English questions relative to other display English questions more often than factual Thai questions relative to other display Thai questions.

Nonetheless, this difference is not statically significant $t(8) = 1.23$, $p > .05$. Comparing the proportion of factual English and Thai questions to total display questions in the one EMI lesson, the proportion of factual English questions to total display questions in one lesson ($M = .37$, $SE = .06$) is higher than the proportion of factual Thai questions to total display questions in one lesson ($M = .29$, $SE = .05$). This difference is not significant $t(8) = 1.04$, $p > .05$. The results show no significant differences in factual English and Thai questions in EMI lessons.

Table 4

Proportions of Types of Teacher Questions to Total Display Questions in the Same Language in English as Medium of Instruction (EMI) Lessons divided by language(s) used

Teacher	1		2		3		4		5	
Display Questions	Eng	Thai	Eng	Thai	Eng	Thai	Eng	Thai	Eng	Thai
a) Factual	.70	.46	.84	.63	.79	.92	.61	.65	.85	.56
b) Yes/No	.08	.04	.03	.16	.11	.06	.29	.27	.15	.36
c) Alternative	.06	0	0	.05	.02	0	0	0	0	0
d) Reasoning	.02	.04	.03	.05	.05	.01	.03	0	0	.02
e) Word Meaning	.15	.46	.09	.11	.04	.02	.06	.08	0	.07

In EMI lessons 2 to 5, the number of Yes/No questions asked in Thai are higher than those asked in English. Moreover, the teacher in EMI lessons tended to ask questions about word meaning in Thai rather than English. This finding may suggest that the teacher tends to use L1 to check students' understanding of word meaning.

In EMI lesson 1, four out of eight word meaning questions in English were questions asked about the same word "endotherm" (Example 3). The teacher repeated and reframed the questions because she did not get a response from students or received wrong responses. In another instance, she asked the word meaning question in English first and got no response; thus, she asked again in Thai. She still did not get any student response; so she went on to tell them the meaning of the word.

Example 4

Teacher: The next group we call class Aves นะคะ (Polite Marker) Aves. This kind of animal they are the first group of animals that we call endothermic. What does it mean endotherm?

Teacher: Endotherm what does it mean? (Action-write on the board) What does it mean? It's like an animal like us like human. What does it mean?

Students: สัตว์เลือดอุ่น [Warm-blooded animals]

Teacher: That is not the meaning. That is what the word is in Thai. That's not the meaning.

Student: Warm-blooded

Teacher: Endothermic. มา warm-bloodedอีก [(I asked about) endothermic. But you still answered warm-blooded.]

Student: Mammal

Teacher: This one is not a mammal. But they are endothermic animal or endothermic vertebrate. The animal? The animal?

Students: (Inaudible)

Teacher: Which when the temperature outside the body change, what is the temperature thirty seven point five degree Celsius all the time right. What do we call that?

Student: Maintain

Teacher: We can maintain maintain the body temperature. They can maintain the body temperature alright. This is what we call endotherm or endothermic animals or endothermic vertebrates.

Note. Translations are in brackets. Additional descriptions and/or explanations are in parentheses.

Table 5
Types of Teacher Questions in Thai as Medium of Instruction (TMI) Lesson

Types of Teacher Questions	1-2 (Double-period)	3-4 (Double-period)	5
Display			
a) Factual	52	25	25
b) Yes/No	1	0	3
c) Alternative	1	0	1
d) Reasoning	0	1	0
e) Word Meaning	0	0	0
Genuine			
a) Opinion	0	0	0
b) Information	0	0	0

All teacher questions found in TMI lessons were display questions. No genuine question was found in all five observed lessons. Similar to EMI lessons, most of the questions in TMI lessons were factual questions. One difference is that there was no question about word meaning in TMI lessons, while word meaning questions were present in all five EMI lessons.

Table 6
Proportions of Types of Teacher Questions to Total Display Questions in Thai as Medium of Instruction (TMI) Lessons

Teacher Questions	1-2 (Double-period)	3-4 (Double-period)	5
a) Factual	.96	.96	.86
b) Yes/No	.02	0	.10
c) Alternative	.02	0	.03
d) Reasoning	0	.04	0
e) Word Meaning	0	0	0

The proportion of factual questions to total display questions in each TMI lesson ranges from .86 to .96. On average, the proportion of factual questions to total display questions in TMI lessons (M = .93, SE = .03) is higher than the proportion of factual questions to total display questions in EMI lessons (M = .66, SE = .03). This difference is statistically significant $t(6)$ =

6.38 , $p < .05$. This result shows that compared to other types of display questions, factual questions were generally used in TMI lessons more than in EMI lessons.

Eliciting Response in the Alternate Language in EMI Lessons

Across five EMI lessons, there were a total of 23 instances in which the teacher asked questions and elicited responses in the alternate language. The questions that elicited responses in the alternate language refer to questions asked in Thai that elicited responses in English and vice versa. Questions in these instances can be categorized into four types:

1) Questions about scientific or academic names,
2) Questions about non-academic word meaning,
3) Factual questions, and
4) Genuine questions (asking for information).

The first type asks about factual knowledge but requires students to answer with specific scientific names. The second type asks about the meaning of particular words. The third type asks about factual knowledge that does not require scientific names. The last type asks students for information that the teacher does not know.

Table 7
Frequencies of Questions Eliciting Responses in the Alternate Language

	Question in English Answer in Thai	Question in Thai Answer in English
Scientific names	1	6
Word meaning	4	0
Factual Question	8	2
Genuine Question	1	1
Total	14	9

The majority of teacher questions in English that elicited students' responses in Thai are factual questions. This may be due to the fact that students were not comfortable answering in English or did not have English proficiency to respond in English. On the other hand, the

majority of teacher questions in Thai that elicited students' responses in English were questions about scientific names.

Example 5. Factual Question (Question in English- Answer in Thai)

T: I found the frog or the toad in my garden. No need to stay in the water all the time but they need only a moisture. They can find food away from the water source and they can survive. Alright and more. Think about the next group of animals?

S: สัตว์เลื้อยคลาน [Reptiles]

T: Reptile, alright reptile

Example 6. Scientific Names (Question in Thai- Answer in English)

T: อันต่อไป รูปนี้คืออะไร? [Next picture, what is this animal?]

S: Rhinocerous

T: A rhinoceros ใช่ไหมคะ? [Alright?]

T: เราเป็นสัตว์หลายเซลล์ใช่ไหม เพราะงั้นเราก็มีส่วนที่เรียกว่า? [We are animals with multiple cells, right? Therefore, we have what we called?]

SCT: tissue

T: หรือว่า เนื้อเยื่อนะคะแล้วประกอบไปเป็น ? [Or tissue that makes up what?]

SCT: Organ

Note. Translations are in brackets. Additional descriptions and/or explanations are in parentheses. Utterances regarding the topic of the example are underlined.

The interesting observation in these two examples is that students chose to answer in English even though the Thai equivalent of these words are commonly used. In other words, the English words that students used to answer are not commonly borrowed in Thai discourse. This suggests that using English as a MoI may help students learn academic English words.

Discourse Patterns

The findings are presented according to types of utterances found in EMI lessons. Please note that the translation of the original Thai words and sentences are in brackets and additional descriptions are in parentheses. When the context of the discourse is necessary, the texts illustrating the specific types of utterances are underlined.

Use of display questions. The teacher used display questions to check students' understanding of what she had previously said. The most common pattern found in this study was the teacher using Thai to ask display questions in order to check students' understanding of what she had previously said in English. Using English to check students' understanding of what the teacher taught in Thai was found less often.

Use of command. The teacher used both English and Thai in giving commands to students. This type of utterance has a facilitation function because it does not introduce any new content but rather manages the class or gives students suggestions.

Example 7

Teacher: Remember that Lamprey. จำไม่ได้ก็ไปเปิดดูนะคะ [Look it up if you don't remember]

Use of review. The teacher asked students about what was covered in the previous class. In four out of five EMI lessons, the teacher started lessons by asking review questions in English. In one lesson, the teacher did not ask review questions at the beginning but instead went straight to introducing new content. This study found that the teacher asked review questions only in English. Students also answered in English. This could be a teacher's teaching style or it could be her intention to incorporate English in class as much as she can and finds it is easier to use

English at the beginning of the class for review because students have already learned the content from previous classes. Compared to other times in class, students seem to be more comfortable answering in English at the beginning of the class. This may be because questions at the beginning of the class are mostly reviewing questions and students already have some understanding about the content; thus, it is easier for students to answer in English than when they are learning new content.

In Example 8, the teacher asked about the phyla that they had covered in the previous class. The teacher started by asking a simple question with a one-word answer, and then continued to ask students to tell her what these phyla are. However, even when asking a reviewing question, the teacher did not leave students to answer by themselves. The teacher also answered in unison with students. This could indicate that the teacher did not get enough response from students or the teacher was afraid that students were not able to answer.

Example 8

Teacher: From yesterday we taught the phylum how many phylum that we studied yesterday?

Students: three

Teacher: three what are they?

Students and teacher: mollusk, arthropoda, and Echinodermata

Use of reiterate. The teacher often reiterated after introducing new content. Sometimes the teacher reiterated using the same language, but most often the teacher reiterated using a different language from the one she used to introduce the contents. When using the same language to reiterate, the teacher simply used different words and phrases to say the same thing that she had said previously. An example of reiteration using a different language is the teacher

introducing new content in English and saying the same thing using Thai. The function of reiteration is primarily reformulation without new content. Nonetheless, when the teacher reiterated in a different language, sometimes the function includes content instruction as well as reformulation.

In Example 9, the teacher used simpler English to explain "jawless fish." She used the phrase "no jaw" to explain to the students what "jawless" means. In this example, there is no new content introduced in reiteration. In Example 10, the teacher introduced a bony fish in English first and then explained what bony fish is in Thai. In this example, the teacher added new information that she didn't say previously such as "both in freshwater and seawater."

Example 9. Reiterate (using the same language)

Teacher: I give you an example of the fish that we call a jawless fish. No jaw.

Example 10. Reiterate (using different languages)

Teacher: And the other fish that you eat. They are a bony fish หรือปลากระดูกแข็ง [or bony fish.] พวกมีก้างทั้งหลาย เราเรียกว่าปลากระดูกแข็ง ไม่ว่าจะน้ำจืดหรือน้ำเค็ม นะคะนี่คือการแบ่งตามสายวิวัฒนาการนะคะ from the evolution. [They are all the fish with fish bones. We call bony fish, both in freshwater and seawater. This is according to evolution from the evolution.]

Used for relating to students' experience. The teacher used utterances in Thai when she mentioned something related to students' life experience or gave examples of something found in Thai culture. This type of discourse can be for content instruction when the teacher related real life examples as a way to further teach content. However, it can also be for facilitation when the teacher used this type of discourse to engage students in classroom discourse. The reason that the teacher switched to using Thai when relating to students' experience may be because students

would be more familiar with these words and phrases in Thai or it could be because the teacher was not comfortable or does not know how to say these examples in English. In either case, it is implied that the students and teachers' English proficiency limits classroom English discourse.

Example 11

> Teacher: For a bird, the body is not covered with the fur, right. It is covered with a feather. We call a feather.
>
> เราเรียกมันว่าขน ลักษณะที่เป็นขนนกนะ เพราะว่ามันจะมีหลอดขนอยู่ตรงกลาง นะคะ ซึ่งต่างกับfuหรือว่าhair
>
> นะคะ เพราะงั้นนักเรียนลองสังเกตหน้าหนาวเนี่ยผู้ชายรู้สึกเย็นหัวไหม เพราะว่าอะไร เพราะว่านักเรียนผมสั้นนะคะ ครูเนี่ยสบายมาก เพราะนอกจากผมจะยาวแล้ว ผมปิดคอด้วย ไม่เย็นคอนะคะ [We call it feather. Feather has a hollow stem in the middle, which is different from fur or hair. Think about the winter, do you male students feel cold on your head? Why? Because you have short hair. For me, it's no problem. My hair is long and covered the neck. It keeps my neck warm.]

Use of translation. This type of discourse includes literal translation, translation of scientific terms and explanation of word meanings. This type of discourse differs from reiteration because this type strictly deals with words and phrases without introducing new contents. This can include translation of English or Thai scientific words or phrases. The function for this type of discourse can be reformulation or language instruction. The function of this pattern is unlikely to be for content instruction because providing students with Thai translations of English scientific words or Thai translations of academic English words do not necessary provide more explanation or understanding to the original English words.

Example 12

Teacher: we talked about the echinodermata in Thai we call สัตว์ผิวหนาม [echinodermata]นะคะ(polite marker) in Thai some book I just look yesterday they call สัตว์ผิวหนาม [echinodermata]

Example 13

Teacher: And then they can use the fin to creeping. Creeping คืออะไรคะ คลานหรือเดิน ก็คือให้นึกถึงปลาตีนเข้าไว้ ครีบมันแข็งแรงจนกระทั่งมันสามารถพยุงตัวมันเดินได้ใช่ไหมคะ [Creeping what does it mean? Walking or crawling. Think about mudskipper. Its fins are so strong that they can support its body, right.]

Example 14

Teacher: the example of this animal this group of animal, crocodile, lizard, snake and a turtle ok

สัตว์ทุกชนิด lay eggs บนบกนะคะ อย่างเช่น อะไร sea turtle ยังมาlay eggs บนบกเลย ถูกต้องไหม ใช่ไหมคะ เต่าทะเล ไข่ที่ไหน ไข่ที่ชายหาด นะคะ

[All animals lay eggs on land such as what? Sea turtle also lay eggs on land correct? Sea turtles, where do they lay eggs? On the beach.]

In Example 12, the teacher provided the Thai translation "สัตว์ผิวหนาม" for the English scientific word "Echinodermata" but the Thai translation itself does not provide a definition or explanation about what "สัตว์ผิวหนาม" means. The literal translation of "สัตว์ผิวหนาม" is "animal with spiky skin." The word itself does not explain what animals it refers to. In Example 13, the teacher said "they can use the fin to creeping" and she said its translation in the next sentence. In Example 14, the teacher used English words "sea turtle" and "lay eggs," then she said it again in Thai. This is not considered reiteration because the teacher said the literal translations of "sea

turtle" and "lay eggs." In Examples 13 and 14, the teacher did not provide the same content using different words and phrases to help students construct conceptual understanding better, but rather the teacher merely provided literal translations to students. This function seems more like a function for language instruction but it is within the scope of translating words that are necessary for understanding the content.

Used for teaching language. This type uses both English and Thai for language instruction purposes. This type of discourse suspends content teaching to focus on language instruction (Fennema-Bloom, 2010). This type of utterance differs from translation in a sense that this type deals with words or phrases beyond the scope of contents, meaning that the knowledge about these words does not help or hinder scientific understanding. In Example 15, the teacher explained scales on reptile's skin. She then further explained what other meanings the word "scale" has. She explained that scale can also mean the weighing measure, but this knowledge has nothing to do with the content that students were learning.

Example 15

> Teacher: Reptiles look at this structure. They cover with scale. Some of them cover with scale. Scale แปลว่าอะไร? [Scale, what does it mean?]
>
> Students: เกล็ด [Scale]
>
> Teacher: เกล็ด แปลว่าอะไรได้อีก? แปลว่า? [Scale what is the other meaning? It means?]
>
> Student:ตาชั่ง [A balance]
>
> Teacher: ตาชั่ง เขาอ่านว่า บาลานซ์ แปลว่า เครื่องวัดความยาวหนึ่งเมตร ได้ไหม เรียก สเกล ใช่ไหมคะ [A Balance it is pronounced balance. It means weighing measurement call scale, alright.]

Using Thai question words. This is a form of code-switching in which the teacher uses Thai question words in English sentences. The function for this type of utterance can be facilitation if the teacher used Thai question words to get students' attention. The function may also be habitual as a result of the teacher's discourse style as a bilingual speaker.

Example 16

Teacher: Archia can survive in extreme environment ใช่ไหมคะ [Is it right?] extreme environment for example very hot place or we call them a thermophilic ใช่ไหมคะ [Is it right?]

Questions from students. One interesting observation is that all of the questions from students were in Thai. Even though, the language of instruction for this class is supposed to be English, students were found to use only Thai when asking questions.

Example 17

Student: sand dollar มันคืออะไรครับ? [Sand dollar, what is it?]

Discussion

To summarize, there are several discourse patterns found in EMI classrooms. First, at the beginning of each lesson, the teacher tended to use more English than Thai as evidenced by the teacher asking review questions in English at the beginning of each lesson. Students also seemed to be more comfortable using English at the beginning of each lesson. This could be because it was easier for students to answer in English about something they had just learned in previous lessons. Second, the teacher often used reiteration. The teacher generally introduced the new content in one language and reiterated the same content in the other language. Sometimes she used English first, and sometimes she used Thai first. There is no fixed pattern for which language she used first. The teacher also used translation, which in this study includes literal

translation, translation of scientific words and explanation of word meaning. Another pattern is that the teacher switched to using Thai when she wanted to relate to students' experiences or provide examples from Thai culture. Moreover, the teacher sometimes switched the focus from teaching science content to teaching language. Last but not least, the fact that all questions asked by students were in Thai may suggest that students were not comfortable asking questions in English. Additionally, the teacher tolerated students asking questions in Thai. Thus, the students were not challenged to use English in formulating questions.

Findings from this study confirm other findings regarding strategies used in EMI classrooms. For instance, the teacher in this study used Thai to relate to students' real life experience. In the study with Malaysian pre-service teachers, the teachers indicated using examples and analogies that students were familiar with and using students' L1 (Chinese) to provide these examples (Mohd. Saat & Othman, 2010). In the study of teaching science to Spanish-speaking children, the teacher used students' L1 (Spanish) to help clarify terms and explain concepts. (Reyes, 2008). The EMI teacher in this study also used similar strategies by using code-switching between languages to introduce new terms and concepts.

Findings about student responsiveness show that using English as a language of instruction can result in fewer responses from students. According to Mortimer and Scott (2003), classroom talk facilitates the meaning-making process which lies at the heart of learning. Thus, the results suggest that using English as a language of instruction may decrease teacher-student interactions and classroom talk, which in turn can negatively affect the learning process. The student responsiveness in this study is also similar to what was found in Russian bilingual science classroom where students whose L1 was not English were reluctant to participate in English-medium lessons (Lemberger, 2002).

Based on student responsiveness, this study shows that allowing students to participate using their L1 can help increase students' class participation. However, this strategy may not give students opportunities to practice using academic English in science (Buri, 2012). In a study with Spanish ELLs, Reyes (2008) found that the teacher could use Spanish to help students develop science discourse in both oral language and literacy. She concluded that allowing students to use their L1 could help in learning academic English discourse in science. Further studies are needed to investigate how to use students' L1 to improve students' academic language skills in L2.

The EMI teacher used a variety of strategies to help students understand content. Several strategies involve using students' L1 such as translation and reiteration. Even though the use of L1 in such strategies may help increase students' understanding of content, it might not be best for students to acquire academic English competency (Buri, 2012). The EMI teacher seems to have a repertoire of teaching strategies focusing on either content or language or both. One way to help teachers to choose the appropriate strategies may be to make the goals of each science lesson more salient. For example, if the aims of science classes are both students' knowledge and academic English language acquisitions, the teacher may decide to use L1-invovled strategies in the first few lessons introducing new concepts and use L2-involved strategies in later lessons to give students opportunities for practicing academic English.

Limitations

One of the major limitations of this study is that the EMI and TMI classes had different teachers and groups of students. Therefore, any comparison between EMI and TMI lessons is limited because observed differences might be due to other factors such as the teacher’s individual teaching style, characteristics of students, among others. Moreover, the nature of EMI and TMI lessons were different in many ways. For instance, the number of students in the TMI

class was almost double the number of students in the EMI class. This difference alone might have affected several findings such as the frequency of teacher questions, the student responsiveness to teacher questions, the frequency and types of teacher-student interactions. Another important difference is that the EMI class had better facilities than the TMI class. In the EMI class, there was a computer and a projector for the teacher to use, while there was none in the TMI classroom. Additionally, the EMI classroom was a closed room with air-conditioners, therefore less noisy than the TMI classroom with opened windows. These differences might have influenced the outcomes of the study.

The findings from EMI lessons support the notion about the camera effect. Stigler, Gallimore and Hiebert (2000) asserted that even though it was possible that the teacher behaved differently because of the presence of the camera, it was highly unlikely that the teacher would be able to change his or her behavior merely because of the presence of the camera. The findings about frequency of teacher questions in EMI lessons show that the teacher asked more English than Thai questions in the first two lessons, but she asked more Thai than English questions in the last three lessons. Similarly, the rate of English questions is higher in lessons 1-2, but lower in lessons 3-5 compared to Thai questions. This may be because the teacher knew she was being observed as an EMI teacher; thus, she might have tried to use English more often than usual. As the observations continued over the two-week period, it was possible that she might have reverted back to using English and Thai languages in her usual way. In future studies, it may be appropriate to discard the first few recordings if the goal of the studies is to capture authentic teaching behaviors.

Implications

Lemberger (2002) found that students tended to participate less in the classroom because of their limited oral proficiency and that students were more comfortable communicating in writing than speaking and listening. Findings from this study suggest that when the goal of science content is primary, other means of classroom communication may be beneficial rather than relying on oral interaction alone. If students avoid using oral communication in an English-medium class, one solution would be allowing students to participate in class using Thai or asking students to express their thinking by writing to help students in constructing scientific conceptual understanding.

Findings from this study can help inform teacher professional development, especially teacher training for teaching ELLs. Several discourse patterns found in this study can be incorporated into teacher training as potential teaching strategies for ELLs such as using students' L1 to relate to students' real lives and allowing students to ask questions using L1. Findings from teacher-student interaction analysis suggest that it may be useful to use both L1 and L2 in order to engage students in longer teacher-students interaction.

Example 18

Teacher: What structure that tells us they are animals?

Student: (Inaudible)

Teacher: They can move ใช่ไหมคะ[Is that correct?] เพราะงั้นสาหร่ายไม่ใช่ โปรติสบางตัว เช่น ยูคลีนา เคลื่อนที่ได้ก็ไปอยู่ใน? [So some seaweeds are not (animals). Some Protists such as Euglena can move so they belong to?]

Student: Animal

Teacher: Animal ก่อน แต่มันมีสีเขียว [Animal at first, but they have the color green.] They can photosynthesize, so they belong to?

Student: Plant

Teacher: Plant at that time and in 1990 ใช่ไหมคะ [isn't it?]

Note. Translations are in brackets. Additional descriptions and/or explanations are in parentheses.

In example 18, the teacher started off by asking a question in English. She got a response from a student and summarized it into an English sentence with Thai question words at the end. She went on to explain that because seaweed cannot move, they do not belong to the animal group. She chose to do this in Thai and asked another question about Euglena in Thai. The student responded to her in English. This shows that when the teacher chose to switch to L1, it does not necessary mean that the students will not use L2. In this case, the teacher might have chosen to use Thai because it was easier to relate to students when she mentioned examples of organisms. When the student answered "animal" in English, the teacher went on to give a hint in Thai (that the organism is green) and then continued the sentence in English. The student then answered in English. This interaction shows that the teacher can use both L1 and L2 to engage students in the interaction and students can still maintain the use of L2.

Conclusions

This study shows that there are differences in classroom discourse when the MoI differs. Overall, the EMI teacher asked questions more frequently than the TMI teacher. The EMI teacher asked questions more frequently in Thai than in English. This study also shows that students tend to be more responsive to questions in their L1 than in English. The findings about teacher-student interaction show that there were more interactions in EMI lessons than in TMI lessons. However, it cannot be concluded that the difference in the number of interactions in EMI and TMI lessons is a result of the difference of language of instruction because teaching

styles, student characteristics, cultural differences, or other factors could also influence the outcome. Nonetheless, both EMI and TMI lessons in this sample reveal that I-R-E is the most common teacher-student interaction style found in Thai science classrooms.

Observations about types of teacher questions show that in EMI lessons, the majority of questions are display questions. In TMI lessons, no genuine question was found. No significant difference was found in types of teacher questions by language in EMI lessons. The findings from discourse analysis suggest that the use of native language in English-medium classrooms may be helpful in certain situations such as checking students' understanding about word meanings and relating to students' experience. In conclusion, this study suggests that using L2 as a MoI can affect classroom discourse including frequencies of teacher questions, student responsiveness, teacher-student interaction, types of teacher questions and teaching strategies.

The study shows the similarities and differences of classroom discourse when the MoI differs. Further studies are needed to help us understand the influence of MoI on science learning. Future research may focus on studies from students' perspectives on how language of instruction affects their science learning. It can also be beneficial to investigate students' cognitive processes in classrooms with different languages of instruction by examining students' writing, notebooks, test results and other artifacts. Further studies in these different aspects of this issue can help us gain a more accurate picture of the impacts of MoI on science learning.

Appendix

Teacher questionnaire

Contact information (Your contact information will be kept confidential)

Name: _____

Phone: _____

Email: _____

Teaching Background

Currently, you are teaching grade _____subject _____

How many years of teaching experience have you had? _____

How many years have you been teaching science? _____

How many years have you been teaching using the current medium of instruction?
_____

What is(are) your educational degree(s)? (e.g. B.Sc., Biology)
_____

Current Teaching Practice

What kind of textbooks have you used in classroom? (Check all that apply)
_____Thai
_____English
_____Bilingual
_____Other, please specify
_____

What is a medium of instruction in your class?
_____Only English
_____Mostly English, rarely use Thai
_____Partly English, Partly Thai
_____Mostly Thai, rarely use English
_____Only Thai
_____Other, please explain
_____

Students

This class is M.____/_____ (identify classroom)

What is the average age of students in this class? _____
How would you rate the average English proficiency of students in this class? (With advanced (5) – being able to use English fluently in academic settings)
_____Beginner (1)
_____Lower-intermediate (2)
_____Intermediate (3)
_____Upper-intermediate (4)
_____Advanced (5)

How would you rate the general academic achievement of students in this class? (Compared to students at the same grade level)
_____Poor (1)
_____Below average (2)
_____Average (3)
_____Above average (4)
_____Excellent (5)

How would you rate the science performance of students in this class? (Compared to students at the same grade level)
_____Poor (1)
_____Below average (2)
_____Average (3)
_____Above average (4)
_____Excellent (5)

Thank you very much for your help.

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