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Mathematics and science teachers' beliefs and practices regarding the teaching of language in content learning

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Abstract

This article presents data from a study examining secondary mathematics teachers' and science teachers' implementation of a language of instruction policy in Malaysia, which made English the medium for mathematics and science instruction. It explores the beliefs of math, science and language teachers, and how these beliefs influence their pedagogical practices in content-based language instruction classrooms. The study uses a mixed-methods approach for data collection and data analysis. Data is analysed using perspectives from content-based language teaching (CBLT) and from research on mathematics and science instruction for English language learners (ELLs). The results indicate that teachers' beliefs about their respective roles as only content teachers or only language teachers limit students' language learning opportunities. Factors such as curricular requirements, exam pressure and time constraints also shape classroom interactions, and have implications for student learning as well. The findings reveal the lack of collaboration between content and language teachers, and the need for sustained professional development concerning content and language integration for both groups of teachers. This study extends work on content-based language teaching to the previously unexamined Malaysian context. Its findings contribute to the ongoing work of improving instructional practices in content-based classrooms to integrate and maximize content and language learning for English language learners.

Keywords

content-based language teaching (CBLT), content-based instruction, mathematics and science instruction, language teachers, teacher beliefs, English language learners

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I Introduction

This article looks at a change in language of instruction policy that is being applied to mathematics and science subjects in Malaysia. This former British colony switched its language of instruction from Bahasa Malaysia, its national language, to English in 2003, with the dual objective of promoting students' mathematics and science learning while increasing their proficiency in English. This policy, called 'Teaching of mathematics and science in English', is commonly known by its Bahasa Malaysia acronym, PPSMI. It mandates a form of content-based language learning (for details concerning the rationale and implementation of this policy, see Chan & Tan, 2005).

The change has important implications for student learning because English is a second or foreign language for almost all teachers and students in Malaysia. It also has serious repercussions on students' academic futures because of the nature of the educational system, which is highly exam-driven, with student achievement being measured via standardized, high-stakes, public exams. At the upper secondary level, student results in the Secondary Examination Certificate (SPM) exams, taken at the end of the fifth year of secondary schooling (16–17-year-olds), determine whether they will be allowed to access higher education. Although students are supposed to be assessed on content in each subject matter, their inability to express themselves in English when responding to short answer or essay questions, which make up about 60% of their marks, negatively impacts their exam performance.

Through the implementation of PPSMI, mathematics and science teachers (MSTs) in this system have had to take on the role of teachers of English for Academic Purposes (EAP) for their students as well. However, teachers themselves needed to improve their proficiency in English to cope with the demands of teaching in English. In order to support the language learning process of MSTs, English teachers have been mandated to function as linguistic buddies via a mandatory 'buddy system' in every school. Within this buddy system, language teachers act as resource persons for MSTs: they run English language workshops, provide oral practice and coaching, correct the English notes and materials that teachers have prepared for their lessons, or simply respond to MSTs' questions about grammar and vocabulary.

Students in Malaysia begin learning English as a second language in the first year of elementary schooling (6–7-year-olds). The students in this study started learning mathematics and science in English only in Secondary 1 (12–13-year-olds). In Secondary 4 and 5, students are given a measure of academic support through English for Science and Technology (EST) courses that focus on reading strategies such as identifying definitions, main ideas and supporting details, transferring information from texts into charts, or taking concise notes. Grammatical elements are taught in this course as well. However, the content in these courses is not linked to content in students' biology, physics, chemistry or mathematics courses.

This article examines Secondary 4 and 5 MST beliefs about language in subject learning within the framework of the PPSMI policy, how these translate into teaching practices and the impact of these practices on student learning. It also looks at the perception of English teachers concerning their role in supporting learning under this policy.

II Literature review

Content-based language teaching (CBLT), or content-based instruction (CBI), is based on Krashen's (1982) theory of the Monitor model and comprehensible input, which argues that language learning happens when students engage in texts and activities that are meaningful to them and relevant to their needs, without explicitly focusing only on the linguistic forms and structures. Evidence from immersion studies (Lambert & Tucker, 1972; Genesee, 1987, 2004; Turnbull et al., 2001; Lazaruk, 2007) and other CBLT studies conducted in a broad range of educational contexts (Stryker & Leaver, 1997) have found that learners develop fluency, functional abilities, and confidence in using their second language. Learners also demonstrate equal or higher performance levels in subject matter learning compared to peers learning in their first language (Morrison & Pawley, 1986; Day & Shapson, 1996). These studies indicate that CBLT can be highly successful, especially in early immersion contexts.

However, other researchers note that comprehensible input and meaningful contexts by themselves are not enough (Crandall, 1987; Snow et al., 1989; Swain, 1996; Brinton, Snow & Wesche, 2004). Lyster (2007), for example, stresses the need for learners to focus on language through form-focused instruction that includes awareness and practice tasks as well as corrective feedback. Moreover, for optimal student learning, language and content teachers must plan and structure language activities in content classrooms (Arkoudis, 2003, 2005; Barwell, 2005a).

Studies on teaching EAP in mathematics and science classrooms involving English language learners (ELLs) tend to support these claims. Research from the area of mathematics and science teaching points to the idea that mathematical and scientific discourses are specific registers (Pimm 1987; Halliday & Martin, 1993), each with their own fields, audiences and modes of communicating. For successful learning of mathematics or science to occur, students must first master the subject's specific discourse (Lemke, 1990). This is consonant with contemporary thinking about language and subject learning, which sees language as a resource for meaning-making and participation in various communities of practice (Lave, 1988; Wenger, 1998). Through dialogue and interaction with other members of their community of practice, learning occurs (Vygotsky, 1986; Wells, 1999). Within this paradigm, language and meaning are mutually constitutive: learners need opportunities to engage in oral and written discourse in their classroom community in order to create their own understandings of the subject domains.

These newer paradigms emphasize that being literate in mathematics and science means not only knowing facts and figures but also being able to participate in these discourse communities (Roth & Tobin, 2007; Solomon, 2009). Therefore, a person who is knowledgeable in these content domains is able to articulate their understandings of concepts, engage in discussions concerning their choices regarding how to solve a problem within the domain and rationally defend these choices when questioned (Lemke, 1990). This is not easy to do, even in the students' first language.

The mastery of the language of mathematics and science becomes more complicated when the students are learning these subjects in their second language (Crandall, 1987). The technical style employed in scientific discourse may be difficult for ELLs because these students have to learn words and language as applied to concepts unfamiliar in their daily

lives. Brown and Kelly (2007) note that 'learning to engage in the discourse of science requires developing new repertoires for interaction with people, texts, technologies, knowledge and assumptions about the world' (p. 283). Sherer et al. (2009) have remarked that many scientific texts are written for a highly literate audience, making them inaccessible for those who do not possess the requisite skills. This is especially true of language learners who may not have access to the same kinds of linguistic resources as first language speakers.

Given the multiple challenges that ELLs have to face in their struggle to simultaneously master academic concepts while improving their linguistic skills (Richardson Bruna & Gomez, 2009), it is surprising that many subject teachers working with ELLs either in mainstream, immersion or content-based classrooms, do not have any specific training in language education (Barwell, 2005a; Richardson Bruna et al., 2007). Barwell finds that while there is support provided to ELLs such as materials and detailed guidance in terms of learning English, very little specifically addresses how teachers can integrate content learning and language learning. Fortune et al. (2008), in reviewing immersion contexts, find little attention is paid to the kinds of pedagogy required for teaching in these classrooms.

In the Malaysian context subject teachers are trained only in approaches to teaching the content for their subjects (Lee, 2004), but they receive no training in language pedagogy. Since the PPSMI policy adds a linguistic dimension to their classes, these subject teachers are given support to improve their English proficiency as part of the PPSMI initiative.

In the absence of formal training on integrating content and language teaching, it can be argued that teacher beliefs become a crucial factor guiding their classroom pedagogical practices. Studies across both language classrooms and subject matter classrooms demonstrate that teachers' beliefs are determinant in the planning of lessons, and the teaching and learning activities that happen in the classroom (Clark & Peterson, 1986; Johnson, 1992; Pajares, 1992; Sato & Kleinsasser, 1999; Borg, 2003; Sullivan & Woods, 2008). Nespor (1987) points out that belief systems are foregrounded when teachers try to solve problems that are ill defined and for which they do not have much background knowledge. It is therefore important to investigate the beliefs of Malaysian MSTs concerning language and content learning as these beliefs determine what kind of content-based language teaching happens in mathematics and science classrooms.

III Methodology

1 Research questions

The questions posed in this article are as follows:

1. What are Malaysian mathematics and science teachers' beliefs about
    a. their pedagogic role?
    b. the role that language plays in the learning of their respective subjects?
2. How do these beliefs translate into linguistic practices during teaching?
3. What are language teachers' beliefs about language in content learning, and what role do they see themselves playing in supporting the teaching and learning process within PPSMI?

The study that this article is based on employed a mixed-methods approach that included both qualitative and quantitative data collection and analysis (Creswell, 2009). The quantitative data was obtained from a survey of teachers from three different states in Malaysia. However, this article reports only on qualitative case studies (Yin, 2009) that were built from data gathered at two secondary schools. More specifically, this article focuses on the data that emerged from the teacher interviews and classroom observations conducted as part of these case studies. While the teacher interviews allowed the researcher to investigate teachers' beliefs regarding their role in offering language support during content instruction, through immersion in the daily routines and working conditions of MSTs, the case study allowed for better comprehension of how factors such as pedagogical resources, time, and student abilities also play a part in how teachers implement PPSMI in their classrooms.

2 Participants

Participants came from the two case study schools (names of both schools are pseudonyms): SMK Gaharu, an urban school, and SMK Kayu Manis, a rural school. These two schools were selected because access to English is different in each of the contexts; English is quite present in urban environments but is rarely used in rural contexts. While many students and school administrators participated in the broader case study involved in this project, this article will report only on the interviews and observations conducted with the Form 4 and 5 MSTs (four science and three math teachers at SMK Kayu Manis; three math and three science teachers at SMK Gaharu) as well as with one English teacher from SMK Kayu Manis and two English teachers from SMK Gaharu.

The teachers in the study agreed to participate on a voluntary basis. While no control was exercised to ensure equality of gender representation, the participants reflect the field reality. Most physics and mathematics teachers are male, while biology and chemistry teachers are a mix of male and female.

3 Data sources

Data came from several different sources. The first of these were semi-structured interviews with MST and English teachers. These interviews explored teachers' training and teaching experience, their perception of the policy and also the impact of PPSMI on their students' academic performance. Data was also obtained via classroom observations. These observations looked for the presence or absence of specific kinds of teacher behavior that were considered helpful in the implementation of PPSMI during classroom teaching, such as the use of advance organizers, providing verbal and non-verbal linguistic support for students, supplying audio, visual and/or multimedia support of concepts being learned and so forth.

Finally, field notes, analysis of school and Ministry of Education documents (curriculum guidelines, Ministry directives, training manuals for MST and so forth) and informal chats with teachers and students in each of the case study schools were valuable sources of data as well.

4 Data collection procedure

Data collection took place over the course of one school year from the months of January to November. This design was selected because it would allow me to see how teaching and learning practices evolved throughout a school year. Three periods of data collection were designated. The first period, T1, was at the beginning of the school year. Data collection started in late January and ended in mid April. The second period, T2, was in the middle of the school year. Data collection in T2 ran from July to August. The third and final period of data collection, T3, took place at the end of the school year, when the SPM exams are about to take place, from October to November.

5 Interview and observation procedures

In each of the case study schools, Secondary 4 and 5 MSTs were observed and interviewed once during each of the three periods of data collection: T1, T2 and T3. Interviews usually took place during MSTs' free periods in the school staff-room or any other available room. The interviews were digitally recorded. Observations of classroom teaching were generally conducted directly before the interviews. This order could not always be respected due to the teachers' time constraints. Depending on the type of lesson being conducted, these observations took place either in science labs or classrooms. In order to disrupt classroom activities as little as possible, I always placed myself at the back of the class, out of the direct line of vision of the students. All observations were videotaped. I completed an observation grid as the lesson progressed. In addition to interviewing and observing the teachers in class, I spent one to two weeks in each school, getting to know more about the school (its history and ethos, and also the physical surroundings), its staff (teaching and support staff as well) and students.

I interviewed English teachers in each school as well because they play an important part in the implementation of PPSMI. One English teacher who taught English for Science and Technology (EST) in SMK Gaharu was also interviewed and observed (without videotaping) doing classroom teaching. I attended and took notes on one English for Maths and Science (EMS) training session conducted by English teachers for MST as part of the buddy support system in each school.

6 Data analysis

a Teacher interviews: I listened to each interview twice before starting coding. The interviews underwent a two-step coding process (Strauss & Corbin, 1998). First, open coding was done to identify sections containing main themes of interest such as their views of themselves as subject teachers, their comfort with the English language, their opinions on students' linguistic proficiency and so on. Then, these sections were selectively transcribed. Specific parts of the text were coded again to represent sub-themes to which the statements belonged (axial coding).

After the coding process, a constant comparative method (Lincoln & Guba, 1985) was used to compare individual teacher's responses across themes and sub-themes across data collection periods. The same method was used to compare

different teachers' responses within the same data collection period. It was used once again to compare and contrast the responses across participants across data collection periods.

b Classroom observations: A procedure similar to that used for the interviews was employed for the videotaped observations. Each videotaped lesson was viewed twice before coding or transcription began. After the process of open-coding, the notes in the observation grid were re-read for incidences of language use (by both students and teacher) that happened during teaching. This was helpful as an advance organizer for the more detailed axial coding. The coding at this stage focused mainly on categorizing language use events by answering questions such as:

- Did teaching happen in English and/or Bahasa Malaysia?
- Did teachers use translation, code-switching or other ways to help students understand?
- Who initiated translation/code-switching/code-mixing?

Teachers' means of preparing students for their Form 5 high-stakes exams were also coded. The coding was related to specific queries that I had concerning classroom interaction. For example:

- Did teachers lecture, conduct small group and/or pair work?
- Did they bring in other materials or rely only on textbooks or exam revision books?
- Were students given time and opportunities to discuss and ask questions?

Once again, the constant comparative method was used for each teacher in order to compare their pattern of language use and exam preparation during classroom teaching over the three data collection periods. These patterns were compared across participants within the same school as well as between the two case study schools.

IV Results

The results of interviews and classroom observations from the case study schools are presented here. All participant names are pseudonyms. In Malaysia, the honorific 'Encik' and 'Puan' are the equivalent of Mr and Mrs in English, respectively. Original quotes are in English if no translation is indicated.

For research question (1a), concerning teacher beliefs about their pedagogic role, mathematics and science teachers' responses indicate that they see themselves first and foremost as subject matter teachers. This is not unusual given that, until the implementation of the PPSMI policy, all of them had only been trained in subject content teaching. Their principal pedagogical focus in the classroom, therefore, is on teaching content. Puan Salmiah, a chemistry teacher from SMK Gaharu, explains that although she understands the importance of language in the teaching and learning process:

> … saya utamakan konsep sains, bukan bahasa yang saya tekankan di sini. Jadi konsep itu penting. Jadi selagi konsep tidak dikuasai, saya tidak boleh ubah topik.
>
> Translation: I privilege science concepts; language is not what I prioritize here. So, the concept is important. As long as the concept has not been mastered, I cannot change [i.e. move on] to another topic.

Also, because they work within an exam-driven education system, both mathematics and science teachers are very concerned with subject matter mastery and student achievement. For them, this is usually reflected in student grades on internal exams, but more importantly, on student performance in mandatory, high-stakes exams administered by the Ministry of Education such as the SPM. Subject teachers willingly accept the responsibility of preparing their students to achieve good grades in the subjects they teach, and they work hard to achieve a high percentage of passes among their students.

Concerning research question (1b) as to what MST believe the role of language in content learning is, there are clear differences between mathematics and science teachers in this matter. We begin by looking at the beliefs expressed by mathematics teachers. For these teachers, language is not very important for learning the subject. It is a peripheral preoccupation or not a preoccupation at all when teaching their students, even within the CBLT framework of the PPSMI policy. The statement below from Encik Hamdan, a mathematics teacher in SMK Gaharu, indicates how the mathematics teachers typically consider language:

> Sebab saya ajar Matematik, Matematiks tak da sangatlah PPSMI ni … So Matematiks tu banyak number … Sebab, write sentence tu, buat apa – only numbers.
>
> Translation: Because I am teaching Mathematics, Mathematics doesn't have much of this PPSMI … So, Mathematics [uses] lots of numbers … because what's the point of writing sentences – only numbers.

Their perception that the process of learning mathematics is not strongly linked to language impacts the way mathematics teachers evaluate their students as well. When discussing how he grades students, Mr Ramachandran, a mathematics teacher from SMK Kayu Manis, stated, 'I'll only look for facts. The language is the secondary part there. So we don't really bother.' In fact, all the mathematics teachers who were interviewed expressed a firm belief that the surest way for students to become good in mathematics was practice, practice and more practice with problem solving. Speed and accuracy at solving assigned problems were the two main abilities they worked to develop in their students.

Science teachers, on the other hand, had beliefs that were more nuanced concerning language and content learning. As mentioned above, they, like the mathematics teachers, focused on subject matter teaching in their classrooms. However, these teachers also realized that since their students were learning in a second (and, for some, a third or fourth) language, the deployment of linguistic resources also played a crucial role in the pedagogical process. Mr Wong, a physics teacher in SMK Gaharu, put it this way:

> Actually facts and figures are important, but when, when you want to explain to [students], you must say it, you need a sentence construction first.

These concerns are reflected in the issues that science teachers raised concerning the assessment of their students' subject matter abilities. Mr Ang, a chemistry teacher from SMK Kayu Manis, explained while speaking about the difficulties in preparing students to answer exams:

> Is he able to express himself, correctly? Certain key words, did he use it? … So my challenge is to make sure that he … understand[s] … and that he's able to express his ideas.

Given these different viewpoints on language, what can be said about question (2): How do these beliefs translate into linguistic practices during teaching? Classroom observations show that these differing beliefs do in fact lead to the implementation of varying classroom practices. Mathematics and science teachers' pedagogical approaches in class were consistent with their beliefs about language and content learning.

In mathematics lessons, there was an almost invariable pattern. Teachers began by introducing the topic or sub-topic they were going to teach during that lesson. This was followed by an explanation of key concepts and terms. Teachers then proceeded to demonstrate how to solve a specific type of problem related to the topic. They usually broke the demonstration down into the specific skill components required for solving a particular kind of problem. As Encik Hamdan put it, 'One example, one skill, in one exercise.' Practice sums, consisting of variations of the same type of problem demonstrated, were then assigned to students. After an appropriate amount of time for students to work on these sums, students were then called upon to come up to the board to display their work. Lessons usually ended with students being assigned a large number of problems for homework.

Math teachers were observed going to individual students' desks to provide additional explanations (usually in Bahasa Malaysia or, sometimes, in the student's L1 if the teacher spoke it) or to help with working out sums, but there was no effort on their part to incorporate classroom activities that could also explicitly promote students' linguistic development. Even though the Ministry of Education supplied pedagogical CDs containing lessons and extended activity sequences in English, mathematics teachers often stated that these lessons simply took up too much time: 'I don't use the IT stuff very often because it's going to make my lesson a little bit slower' (Encik Nasir, mathematics teacher in SMK Kayu Manis).

Teaching practices in science classrooms, on the other hand, were more varied and demonstrated more efforts on the part of teachers to incorporate linguistic elements into their content teaching. Although science teachers acknowledged that they were not 'language experts', many of them used teaching methods that encouraged students to speak in English in class, attempted to model scientific language for their students, or provided students with more linguistic input related to the topic being taught. Examples of these include:

- Pair–share–report (Mr Ang, chemistry, SMK Kayu Manis): For this class, Mr Ang had assigned students a chapter to read at the end of a previous lesson. He invited students to form pairs to discuss what they had learned from reading. Various pairs were asked to report on their discussion to the rest of the class.

- Demonstrating and scaffolding students' understanding of the scientific method during a whole class discussion (Mr Wong, physics, SMK Gaharu): For this lesson, Mr Wong carefully presented key steps and terms such as hypothesis, variables, instruments, and so on. For each of these steps and terms, he invited students to participate in the discussion by posing open-ended questions such as 'What is a hypothesis?' Although he himself did not call it that, he was modeling a genre in scientific discourse, namely, the scientific report.
- Use of a pop song as prompt to discuss environmental issues (Puan Sarjit, biology and science, SMK Kayu Manis). In this lesson, Puan Sarjit wanted to discuss the idea of global warming and, more specifically, the 'greenhouse effect'. She used her laptop and LCD projector to play the song 'Earth Song' by Michael Jackson on the catastrophic consequences of pollution, wars and mass consumption. Its vivid images and lyrics seemed to capture the attention of the students quite effectively, and provided a starting point for the class discussion that followed.
- Puan Sarjit also gave an impromptu 'mini-language lesson' to her students as a discussion took place in class about Bernoulli's Principle (concerning velocity and the pressure exerted by moving fluids):

Fuad:	(continues reading) this cause the water level in tube X to be the (*Another student, Fikri, calls out*, 'Higher') to be the highest.
Puan Sarjit:	Yes.
Fuad:	And the water in tube Z to be the low.
Puan Sarjit:	(with emphasis) low-est. High-est. Because you're comparing between three, right? So I'll repeat the answers. Thank you.

However, this specific attention to and teaching of linguistic elements described in Puan Sarjit's class was something rarely seen in all the classes observed.

1 Supporting role of English language teachers

English language teachers in both schools played an active role supporting the language learning of mathematics and science teachers. These language teachers were quite willing to play a role as language resource persons for MSTs in the buddy system for which they often coordinated language learning activities and workshops after school hours. Even as resource persons for content teachers, however, they set specific boundaries. For example, one ESL teacher and buddy system coordinator stated, 'You see, English language teachers can only help them with language, right? Language issues …' (ESL teacher and buddy system coordinator, SMK Gaharu)

This is because they see themselves first and foremost as language teachers, which is what their basic teacher training prepared them to do. In English classes, they teach students grammar, literature response and essay writing. Many of these language teachers are not comfortable engaging with math and science content and do not draw on it during their language lessons. A striking example of this is seen in the EST course that I observed at SMK Gaharu. In this lesson, the English teacher was trying to teach students how to use sequencing words such as 'first', 'then' and 'after that', which are found frequently

in texts regarding mathematical procedures or scientific experiments. The teacher chose to use a recipe for making a type of noodle soup instead, which may not seem unusual given that recipes are often used to teach sequencing words in language classrooms. However, EST is a course aimed specifically at teaching students English for academic purposes in the domain of science and technology. Given that sequencing words abound in scientific and mathematical procedures, it was surprising that there was no attempt to link these words to a mathematics or science context. Moreover, an examination of the syllabus for EST courses revealed that the topics were not selected on the basis of what students are learning in their mathematics or science courses. In fact, Puan Salmiah pointed out that the topics presented to students were usually at a more advanced level intended for pre-university courses.

2 Commonalities in practices across classrooms

All classes observed, regardless of whether they were content or language classrooms, remained very teacher-centered. Activities that allowed students to verbally or textually explain or explore their conceptions (or misconceptions) of the ideas presented by their teachers, either individually or among peers, were not often seen. Instead, teachers often used translation, simplification or key words as the quickest ways to help students understand. This was also due to the time constraints imposed by the educational system itself. Mathematics and science teachers were especially conscious of the need to complete the entire syllabus so students would be ready for their exams. Mr Wong explained:

> With the trial exam coming up, we need to complete the syllabus. If we cannot complete the syllabus, we need to rush through, rush through. And then, after the trial exam, then we try to, more or less, amplify the concept. Try to make it more detailed … In case the questions come out, they haven't been taught, parents will start to complain later … Speeding through, just for the sake of the trial exam.

V Discussion

The results from interviews and classroom observations in the two schools show that although the PPSMI policy entails the need to work on both mathematics and science content and on language skills, neither content teachers nor language teachers were able to systematically incorporate these two elements into their teaching. These results are consistent with what has been found in other contexts when language is expected to be learned alongside subject matter in classrooms (Davison, 2006). However, what is problematic in these situations, is that teachers often define their pedagogic knowledge through the lens of their subject disciplines (Arkoudis, 2005). This is especially true of teachers in secondary and post-secondary levels of education. Therefore, as Creese (2005) remarks, language and content teachers believed they had separate roles: language teachers engage in language work while the subject teachers focus on subject-matter content. Her ethnographic research on ELLs who had been mainstreamed into regular classrooms in the UK demonstrated that even though both language and content were supposed to be developed in these classrooms, this was not the case. Similar to

findings in this study, she reported that the majority of language work focused on defining key concepts in content areas; there were very few instances of teachers explicitly addressing linguistic form. Also, as was the case with teachers described here, she found that both language and subject teachers lacked an understanding about how language works to create meaning. Therefore, these teachers did not use opportunities for extending language work to their full potential. Teachers' dichotomous beliefs of language and content is problematic for both the content learning and language learning domains. It leads to a view of language as a conduit or portal, thereby obscuring the role that language plays in construing the subject (Barwell, 2005a, 2005b). A segregated view of language and content also depicts the two as static entities, ignoring the role that teachers and students have in engaging with both these domains to create meaning.

This partially accounts for the lack of student oral participation in the observed classrooms. However, the present study also found that teachers' beliefs about their pedagogical role in preparing students for exams contributed to this phenomenon as well. Curricular and exam pressures, coupled with time constraints, contributed to teachers adopting teaching practices that were time efficient but that restricted opportunities for student language production.

Also consistent with what has been pointed out in the literature is the lack of attention paid to language pedagogy for teachers working on content and language learning in contexts such as immersion (Walker & Tedick, 2000; Fortune, Tedick & Walker, 2008). The focus in CBLT classrooms tends to be predominantly on content and not language (Swain, 1988). As with the Malaysian classrooms described here, Swain (1996) observed that students in CBLT classes speak relatively little and rarely need to give extended answers. This could be due to the traditionally held belief that for subjects such as history, geography, mathematics or science, there is a 'body of knowledge' (content) that exists independently of teachers and learners. Teaching a subject involves a transfer of this knowledge from the teacher to the learner, and language is the conduit through which the transfer occurs: learning is therefore the acquisition of content (Barwell, 2005b).

VI Implications

The results show that there are specific patterns to the beliefs and practices of mathematics and science teachers as well as language teachers. What is evident is that in content classrooms, teacher beliefs concerning language and subject learning exert a strong impact on how they teach. This consequently has implications for what students learn in their classrooms. The implications are especially important in the case of mathematics teachers. Their beliefs and classroom practices, which disregard the importance of language for the conceptual learning of their students, result in a situation in which students are not given the opportunity to master mathematics discourse (Clement & Bernhard, 2005). Fang and Schleppegrell (2008) stress the role mathematics teachers play in introducing students to disciplinary knowledge and the importance of text as the primary medium for producing, storing, communicating and critiquing this knowledge; teachers have to develop the expertise to help students engage with language and texts in their domain. Hancewicz (2005) remarked that, whereas drills may lead to efficiency in problem solving, they do not necessarily entail deeper conceptual understanding for students.

The classroom practices of mathematics teachers in the present study, therefore, may be seen as limiting their students' opportunities for content and language learning.

The constraints on teachers' pedagogical choices due to time factors and exam pressures also impact on the kind of teaching and learning that take place in mathematics and science classrooms. Huang and Normandia (2008) notice that approaches such as translation, simplification or an emphasis on key words are common practices among mathematics teachers. Less linguistically proficient students are trained to select a mathematical operation for solving the problem when they recognize a key word. However, Clement and Bernhard (2005) point out that word problems are often presented to help students develop mathematical reasoning skills. By having students focus on key words in isolation, teachers are simplifying the complex process of problem solving. Students may indeed solve specific problems but fail to develop the desired reasoning skills. Moschkovich (2007) argues that, 'Instruction focusing on low-level linguistic skills, such as vocabulary, neglects the more complex language skills necessary for learning and doing mathematics' (p. 92). The same could be said of learning and doing science.

As mentioned earlier, these content teachers have not received any training in language pedagogy. The lack of planning between language and subject teachers has implications for the learning of both MSTs and their students. MSTs are left to struggle on their own with how to teach both content and language. As the observations of science classrooms show, some teachers do make efforts to incorporate linguistic elements into their subject teaching. However, these efforts are not consistent; there is no larger overall plan to systematically integrate content and language teaching. Given that their students are ELLs, the need to pay attention to both concepts and the forms needed to express these ideas is crucial (Lemke, 1990; Brown & Kelly, 2007; Sherer et al., 2009). The lack of content and language integration in mathematics and science as well as language classrooms reduces the chances for students to verbally and textually engage with the ideas presented in their classes to create their own understandings. These factors decrease students' ability to participate fully in developing mathematics and science discourse, and in becoming fully literate members of these scientific communities (Roth & Tobin. 2007; Solomon, 2009). Moreover, in terms of language, Lyster and Saito (2010) point out that retrieval and opportunities for contextualized practice are effective catalysts for continued language development. Therefore, the teacher-centered classrooms where students rarely produce language might also be hindering student learning.

Teachers' classroom practices also have repercussions for their students' academic futures. MSTs may indeed be helping their students pass the exams at the SPM level. However, as these students progress to higher levels such as college or university, they will be called upon to be more independent and creative thinkers. Consequently, they will need the linguistic ability to express their understandings and knowledge in extended discourse such as scientific papers and lab reports. In fact, part of the Malaysian educational reality is that many students will go abroad to countries such as Australia, Britain or the USA to complete tertiary education. Even within the local context, many science, mathematics and technology courses in universities are conducted in English. Schleppegrell and Colombi (2002, p.140) have pointed out that even if ESL university students do master the content and concepts of the field, their writing often lacks 'the authoritativeness and textual structure that realize the meanings expected in standard

academic English'. At these levels, therefore, the students' lack of linguistic ability eventually becomes a stumbling block.

VII Recommendations

The results of this study reveal how difficult it is for language and subject matter teachers to implement CBLT without high-quality, sustained, professional development. One of the most urgent steps is the necessity of preparing MSTs, who are only trained in subject teaching, to help their students in ways other than the direct translation or simplification methods that are commonly used at present. Language teachers must also undergo professional development that includes basic knowledge of mathematics and science and knowledge of how to support the learning of EAP in these subjects (Fillmore & Snow, 2002).

Both content and language teachers need also to be made aware of how to use language as a tool for learning, not simply as a conduit for transferring facts and formulas. Teachers need to realize the importance of engaging students in disciplinary discourse to master concepts. The teacher-centered classroom can then give way to one where students have opportunities to talk and think like members of the mathematical and scientific community (Richardson Bruna et al., 2007; Roth & Tobin, 2007). For these types of classroom interactions to come into being, MSTs need to be encouraged to learn and experiment with student-centered or inquiry pedagogies which privilege co-construction of knowledge and understanding. They will also have to consider alternative forms of assessment that promote the value of discourse and literacy skills in the content classrooms as opposed to individual displays of knowledge relative to facts and figures.

Formal frameworks that increase collaboration between subject and language teachers should also be introduced. This means language and content teachers will be given the time and resources necessary to work together to plan lessons carried out throughout the year. One such framework could be the Framework of Counterbalanced Instruction proposed by Lyster (2007), where language activities focusing on form and content-based activities can be integrated and complement each other across the curriculum. In this case, planning for existing English courses, such as EST, must include content and language instruction sequences that scaffold each other. Other possibilities include professional development in team teaching skills for language and subject teachers; sheltered content instruction to allow weaker students to work on improving their language as they learn various subjects (Echevarría & Graves, 1998) or adjunct courses as described in Brinton et al. (2004). These measures will help teachers understand and implement pedagogical practices that promote the kinds of learning desired in content-based language teaching, and allow students to participate actively in classroom scientific and mathematical discourse.

VIII Conclusions

While observing teachers multiple times over the teaching of a whole unit as I had originally planned might have provided a deeper and more detailed understanding of MST classroom practices and how these relate to their beliefs, this study nevertheless extends what is known about CBLT by providing a perspective on language learning in mathematics and science classrooms in Malaysia. This is a novel CBLT context that has not

been much studied. The similarity of findings across CBLT contexts emphasizes how, despite very different linguistic and educational environments, assumptions that language learning happens when students are placed in meaningful contexts with comprehensible input persist. The results strengthen the evidence that there is a specific need for teacher professional development, across CBLT programs in both ESL and EFL contexts, focusing on ways of integrating content and language learning.

The results also fill a gap in the literature by contributing to the new and growing literature examining the experiences, beliefs and struggles of content teachers who work with language learners through CBLT (Cammarata, 2010). Besides considering the impact that beliefs have on teaching and learning, this study adds a new dimension to previous literature in that it considers how time and high-stakes exam pressures influence teachers' pedagogical choices in CBLT as well.

The results and discussion reinforce the findings from previous research that it is not enough in CBLT to simply teach subject matter in the target language with the hopes that this will result in learning in both domains. Nor is it even enough to have additional language courses such as the EST to provide additional support for student learning. The results of this study and previous research demonstrate that if these efforts are not coordinated among language and content teachers, the quality of learning provided to students suffers. Conversely, if these two types of teachers work hand in hand, students will finally have the chance to achieve the dual objectives of content and language learning as envisioned under policies such as the PPSMI policy.

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